A STUDY ON FLEXIBLE CLUSTER UNITS FOR REFUGEES CAMPS

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By
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MAAMOUN AMMOUN: A STUDY ON FLEXIBLE CLUSTER UNITS FOR REFUGEES CAMPS

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To my parents…

ABSTRACT

According to the UNHCR reports in 2017, 65.3 million people are forced to migrate away from their homes. The other dramatic identification is that 22.5 million refugees have to survive their lives in other countries refugees' camps.

The shelters that are used in these camps most of the time temporary shelters which are used during natural disasters (earthquakes, fire, floods, etc.). However, it has been proved that refugees spend minimum 5 years in these camps. Some records mention that 2 generations may spend their lives in these inhumane conditions of camps.

All these problems force the review the organization of refugee's camps deeply from the architectural point of view. Conceptually, flexibility in architecture basically aims to satisfy physical and psycho-social needs of users.

This thesis try to discuss the design principles of green refugees camps and focuses on flexible arrangements of shelters. In this study, flexible design of shelters and clusters which considers different family sizes and family needs are developed.

Keywords: Refugees' camps; refugees' needs; shelters; flexibility in architecture; green building

ÖZET

Birleşmiş Milletler Mülteci Yüksek Komisyonu'nun (UNHCR) 2017'de raporlarına göre, 65.3 milyon insan evlerinden göç etmek zorunda kalmıştır. Bir başka dramatik tespit ise, 22.5 milyon mültecinin başka ülkelerdeki mülteci kamplarında yaşamlarını sürdürmek durumunda kalmalarıdır.

Bu kamplarda kullanılan barınaklar, çoğunlukla doğal felaketlerde (deprem, yangın, taşkın vb.) kullanılan geçici amaçlı üretilmiş barınaklardır. Öte yandan, mültecilerin büyük bir bölümünün bu kamplarda en az 5 yıl geçirdiği de ispatlanmıştır. Bazı kayıtlar, bu insanlık dışı kamp koşullarında iki neslin hayatlarını geçirmek zorunda kaldıklarını belirtmektedir.

Bütün bu sorunlar, günümüzde mülteci kamplarının organizasyonunu mimari açıdan yeniden ele almaya zorlamaktadır. Tam da bu noktada,kullanıcıların fiziksel ve psiko-sosyal ihtiyaçlarını karşılamayı amaçlayan esneklik kavramı önemli bir mimari araç olarak görülebilir.

Bu tez, yeşil mülteci kamplarının tasarım ilkelerini tartışmaya çalışmakta ve mülteci barınaklarının esnek düzenlemelerine odaklanmaktadır. Bu kapsamda, farklı kişi sayılarından oluşan ailelere ve yaşam döngüsü içinde oluşabilecek ihtiyaçlarına çözüm üretilmeye çalışılmıştır. Aynı zamanda, kişi sayısına bağlı alternatifli barınak tasarımları yanında esnek küme düzenlemeleri de ele alınmıştır.

Anahtar Kelimeler: Mülteci kampları; mülteci gereksinimleri; barınaklar; mimaride esneklik; yeşil bina

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LIST OF ABBREVIATIONS

CLT: Cross-laminated Timber

DOE: Department of Energy

GRC: Green Refugee Camps

IDMC: Internal Displaced Monitoring Center

IEA: International Energy Agency

LEED: Leadership in Energy and Environmental Design

UN: United Nations

UKGBC: UK Green Building Council

UNHCR: United Nations High Commissioner for Refugees

UNICEF: United Nations International Children's Emergency Fund

CHAPTER 1

INTRODUCTION

In order to mention the importance of thesis subject, it will be useful to give examples from the near history. In 2011, over 6.5 million Syrians have been displaced because of the civil war in Syria. Two million of them have fled to neighboring countries. The United Nations High Commissioner for Refugees (UNHCR) says another 6 million have been displaced within Syria itself since the start of the conflict (UNHCR, 2014), which force them to risk their lives on the way to Europe hopping to find any place to live. However, they do not have any choices, no food, no water, but damaged houses. This homelessness naturally will cause a very serious disease, specially using polluted water and unclean expired food. Some of expected diseases are (cholera, microbial infections, kidney diseases, psychotic diseases and depression, etc.).

According to UNICEF (2014), more than 14 refugees included 3 children were killed in January 2014 in Lebanon and Syria only because of extreme cold weather. This means that those developed countries aren't making good condition camps to protect refugees.

Refugee's camps need electric station, tons of water tanks, and special equipment shelters in order to be livable. That is a huge budget for countries like Lebanon and Jordan. That reflects why always refugees situation are becoming worse day by day. A growing number of Syrian refugees are escaping across the border into Turkey, and then hundreds of thousands of them decide to go on the "Death Trip" to Europe across the Mediterranean Sea from Turkey to Greece, seeking for better live and safer homes. Unfortunately, thousands of them were drowned, and couldn't make it. Internal displaced people inside Syria are not less important or less numbers than the international refugees.

According to IDMC (Internal Displaced Monitoring Center) shows that over than 6,600,000 had internally displaced Figure 1.1.

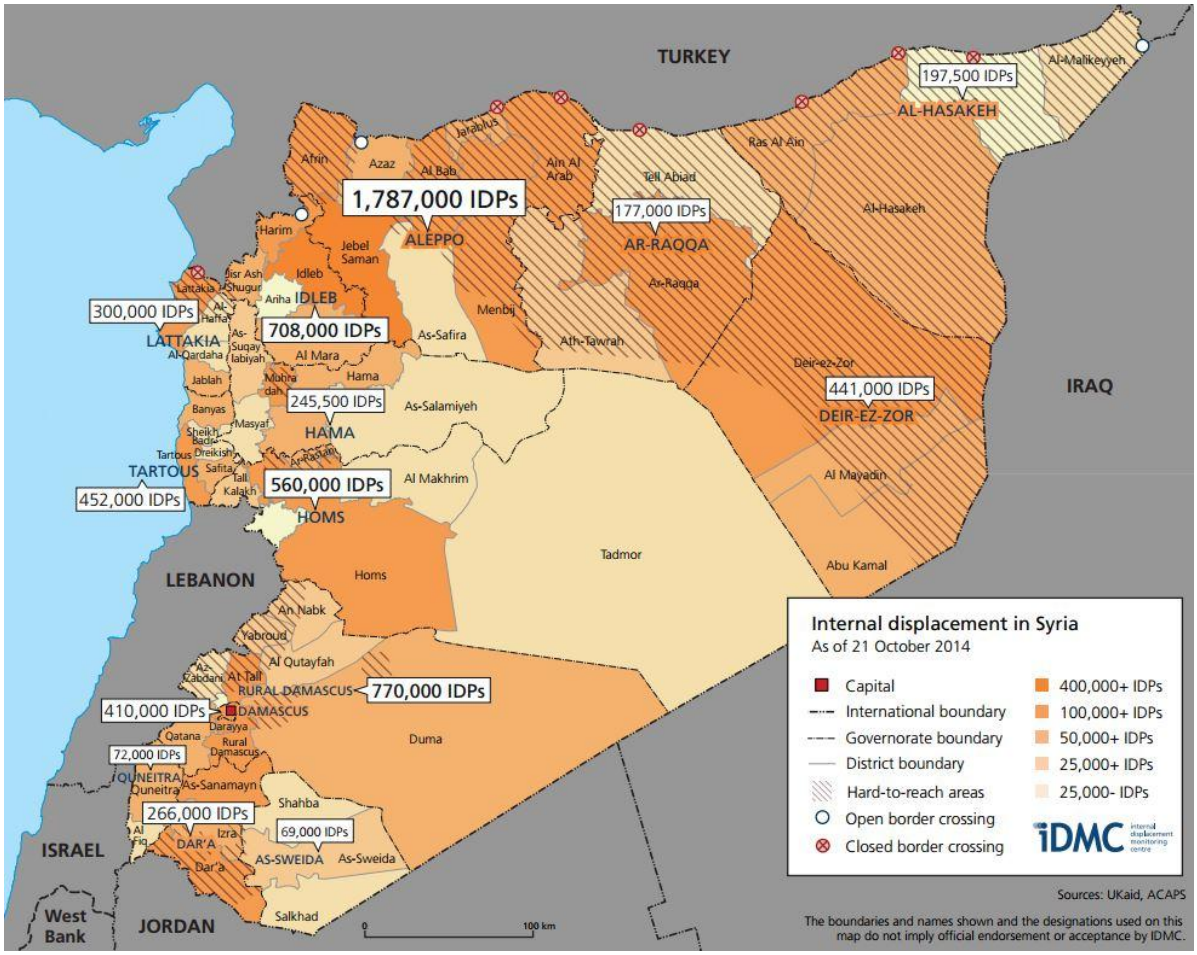


Figure 1.1: Internal displacement in Syria (Internal Displacement Monitoring Centre, 2014)

All of those facts and numbers mentioned above definitely force to overview the planning of refugees' camps again and again from the architectural point of view. In other words, refugee camps should be reconsidered economically, socially and environmentally. Modularly developed shelter units for flexible cluster arrangements can be useful tool in order to overcome these problems.

1.1 Thesis Problem

Shelters in most of the refugee's camps do not satisfy people's physical and psycho-social needs. Temporary shelters that are widely used in the camps do not create loyalty on people and most of them are insufficient for long term use.

On the other hand, UNHCR states that all refugees have the right of living in safe shelters which provide opportunity for storing their goods, space for privacy and emotional needs. It's also refugees right to have common spaces for their social needs. Meanwhile the other important point is that refugees' camps bring heavy economic burden for the countries.

1.2 Aim of Study

The aim of this study is to develop modular flexible shelter clusters for refugees such that they will satisfy both physical and psycho-social needs of their users. Modular approach together with green design consideration will make proposal both affordable and sustainable.

1.3 Limitations of the Study

Although design principles of green refugee's camps are reviewed in the study, the proposal is limited with the flexible arrangement of cluster units having different family sizes.

1.4 Thesis Overview

Chapter 1 defines the scope and purpose of the study. Chapter 2 reflects theoretical framework for physical and psycho-social needs of refugees together with the principles of flexibility in architectural design. Chapter 3 reviews literature on design on design principles of refugee's camps together with green design concepts particularly on the use of materials. Articles, journals and other academic sources related to the research area are examined. In addition selected refugees camps with their shelters types are analyzed.

Chapter 4 is a case study on alternative arrangements of planning shelter clusters. Arrangements consider different family sizes within the framework of refugee's basic physical and psycho-social needs. Chapter 5 is the conclusion of thesis study. The chapter discusses the results and experiences of case study together with reviews. Recommendations and suggestions for future researches related on the thesis subject have been mentioned.

CHAPTER 2

REFUGEES BASIC NEEDS & PRINCIPLES OF FLEXIBILTY

In this chapter, refugees' basic needs and principles of flexibility will be studied. Different family sizes, different ages and/or different cultures create different physical and social needs. At this point, flexibility as a concept will be the main architectural tool to dominate these physical and social needs within the limited modular spaces.

2.1 Refugees Basic Needs

Refugees basic needs can well be answered in the Maslow's theory as user basic needs. Arcan, (1992) in his book mention's that, in reality, the user needs are abstract and unobservable concept. To understand the user needs, you should understand the relation between people and their behaviors. You should know the reasons for these behaviors. The main objective of the human behaviors is to meet/satisfy the basic needs. "Human needs" are very general concepts. The expectations of people from the environment who use the spaces we designed are called the user requirements in architecture.

The user needs determine the minimum qualifications of a space. The lack of these qualifications of space may cause discomfort for the user and the intended use of space hampered. For example, hunger as a requirement is embodied in the act of eating. "User requirements", are the environmental conditions for the individuals or communities to perform their actions most effectively. User requirements depend on the human anthropometry, the sensory and perceptual dimensions. Refugees basic needs can also be examined under two headings, physical user needs and psychological – social user needs.

2.2 Physical User Needs

Physical user needs are examined as spatial needs, thermal comfort needs, acoustical needs, optical needs, hygienic needs and security needs.

Spatial Needs:The dimensions (static, dynamic and anthropometric), types of activities and related behaviours of people in space see Figure 2.1 for static, dynamic and anthropometric human dimensions.

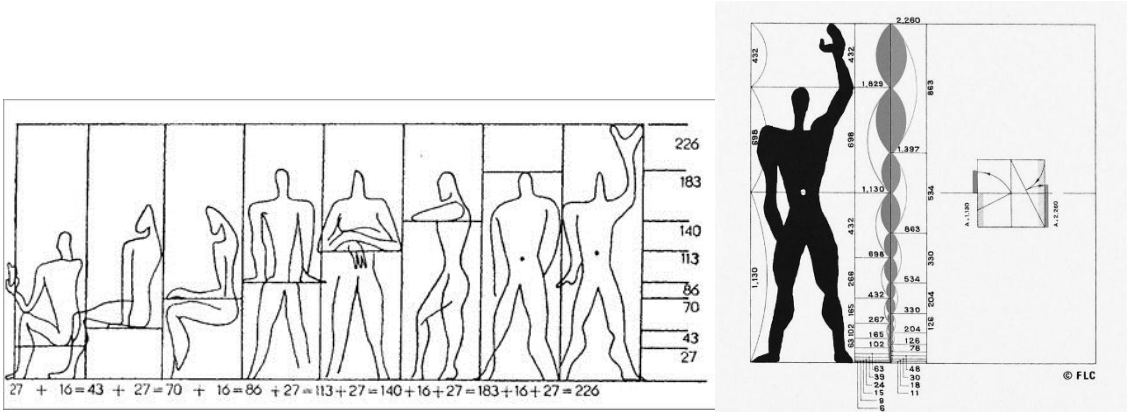


Figure 2.1: Static, dynamic and anthropometric human dimensions (Ching, 2014)

Human activities and therefore spatial needs in terms of activities can also be expressed with modular dimensions. Once modular human activities are matched with modular prefabricated building materials, then fast and economic construction is possible, with efficient space use see Figure 2.2. For modulated dimensions of human activities and for how human activities can be matched with prefabricated building materials see Figure 2.3.

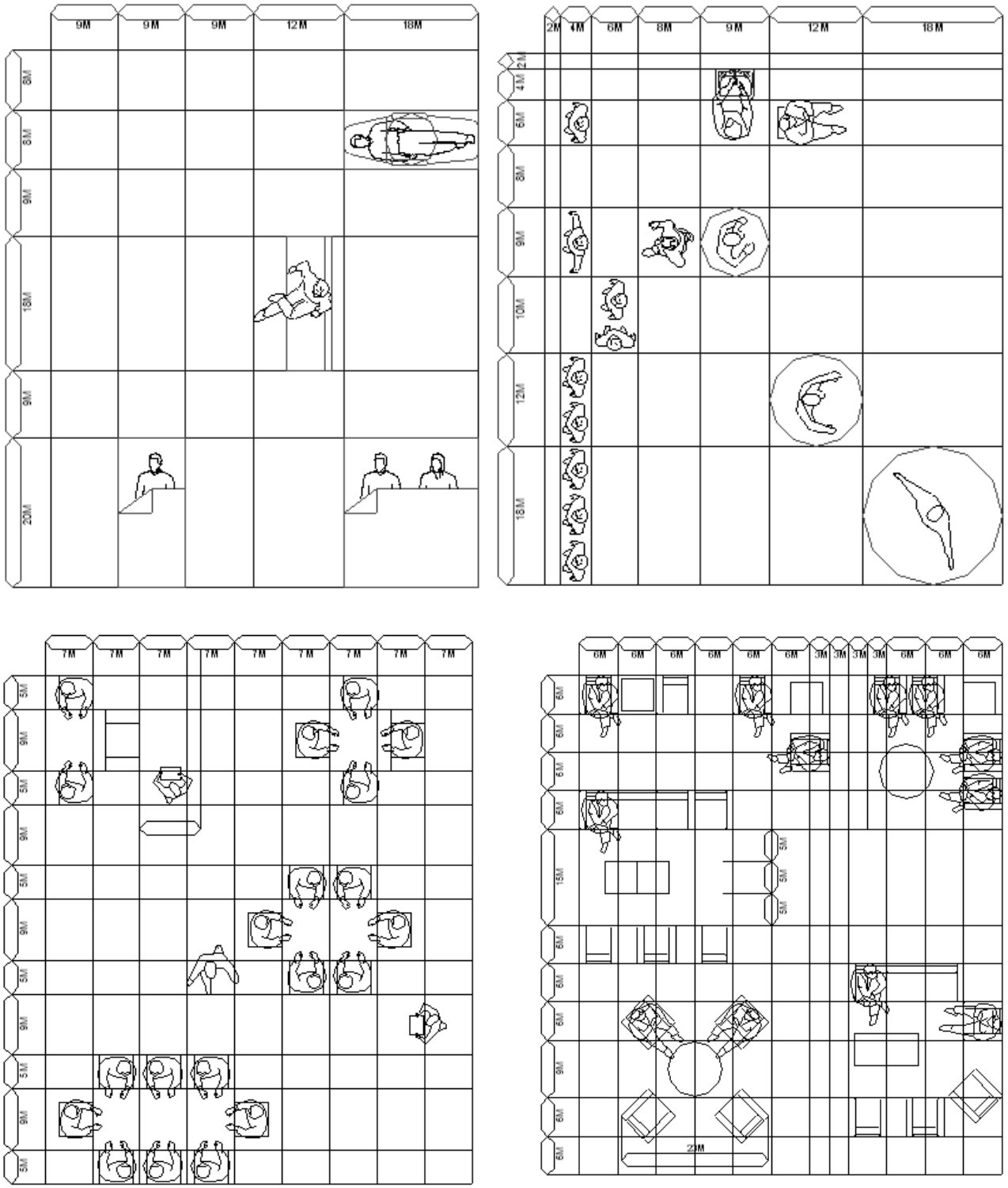


Figure 2.2: Modulated dimensions of human activities (Ceyhan, 1973)

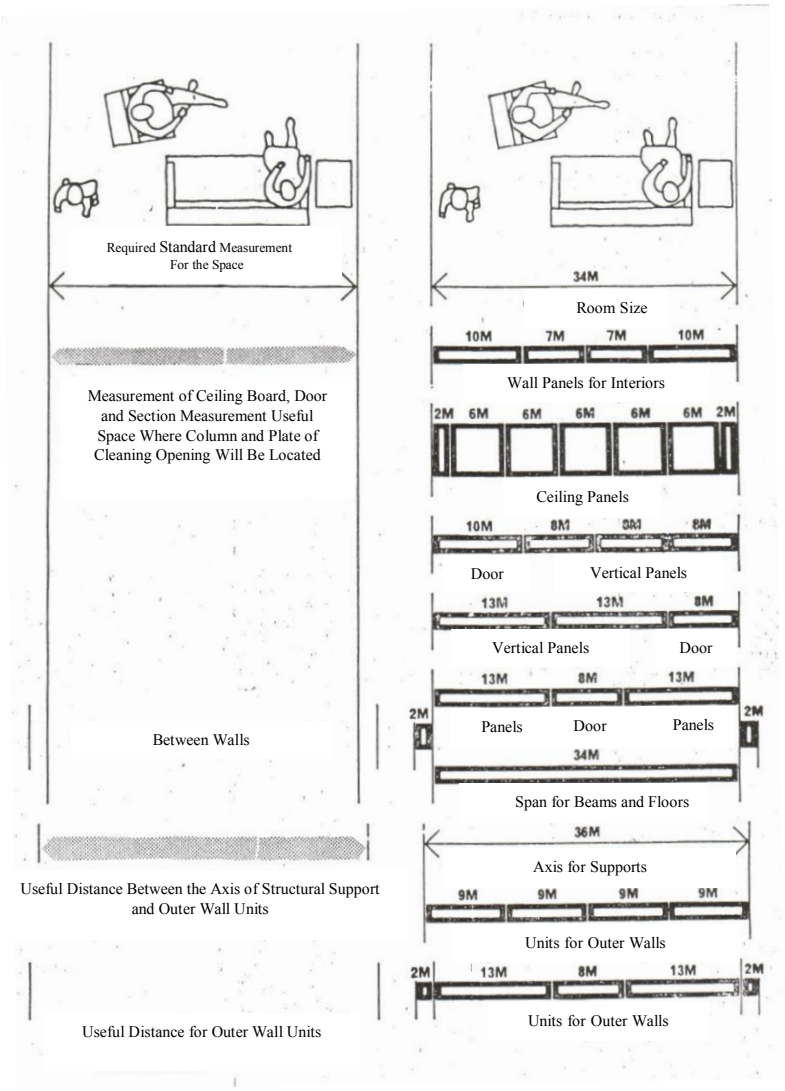


Figure 2.3: Matching modulated dimensions of human activities with prefabricated building products (Kulaksızoğlu, 1980)(Uzunoğlu, 2014)

- Thermal Comfort Needs:Suitable, temperature, humidity and air movement in a space.
- Acoustical Needs:Sound intensity, transmission and reflection properties of the space.
- Optical Needs:Suitable light intensity and illumination level in a space.
- Hygienic Needs:Clean water, garbage and disposals, protection from germs and harmful organisms.
- Security Needs:The stability, protection against natural disasters (fire, earthquake), thiefs and accidents (Arcan, 1992).

2.3 Psychological –Social User Needs

Psychological – social user needs are examined as; privacy needs, behavioral needs, aesthetic needs and social needs.

- Privacy Needs:Acoustical, visual, personal and social privacy
- Behavioural Needs:Personal (45-120 cm),social (120-360cm),public (360-) spaces see Figure 2.4.

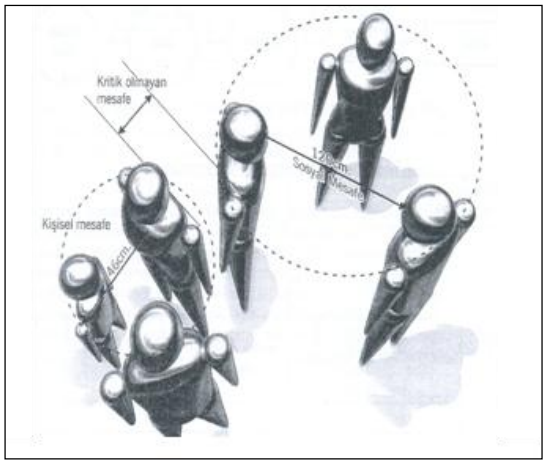


Figure 2.4.Personal and social distance (Bozdayı, 2004)

- Aesthetic Needs:Formal, textural and color features
- Social Needs:Social relations, activities and related needs in a space (Bozdayı, 2004).

2.4 Human Activities in Shelters and Life Cycle

As mentioned before, UNHCR states that all refugees have the right of living in safe shelters like their homes. Therefore, in this thesis, activities in shelter can well be evaluated as activities in typical homes which provide opportunity for storing their goods, space for privacy and emotional needs. It's also refugees right to have common spaces for their social needs. Human activities in a refugee's shelter are as mentioned in Table 2.1.

Table 2.1: Human activities in a refugee's shelter (Arcan, 1992)

Main Activity Group	Related Human Activities
Resting	Sleeping Resting Idling Nourishing Watching TV Listening to music Reading books Conversation
Dining	Food Storing Food Preparing Eating
Hygiene	Discharging Bathing Make – up Sports
Reproduction	Sexual intercourse Infant care Teenage care
Dressing	Dressing Dress maintenance and repair Dress storing Sewing
Cleaning and Repairing	Household cleaning and repair Dish washing Laundry: washing, ironing and repair
Culture and Education	Literacy Homework Communication means (TV, radio, computer, etc.) Conversation
Entertainment	Music Play and dances Hobbies
External Relation	Communication (Telephone, PC, laptop, etc.) Guests (Home entrance) – invitations Food and household delivery
Management	Planning Control

“Life cycle” of a family (or house hold) in a long term stayed shelter or in camp is worth to examine. Depending on time the number of household in a shelter may increase or decrease. The requirements of the users also vary depending on the age groups see Figure 2.5.

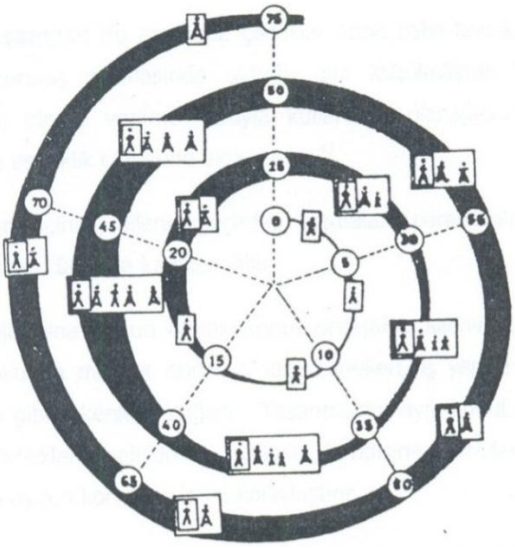


Figure 2.5: Life Cycle – change of needs during life (Ateş, 1988)(Uzunoğlu, 2014)

Change of needs in a shelter during a life cycle can be due to;

- Increase in number of children; another room requirement because of gender differences in children
- Children's work; after a certain age they require a private space
- Increase of requirement for storage in a shelter as time passes and also for hobbies.
- When mother or father of one of the partners (married couple) has to live in the shelter together with them.
- Children (either married or single) leave of shelter.
- Death of grandparents.
- Parents leave of shelter.

UNHCR have mentioned that some families live in refugee camps for more than 20 years. So, in the light of these facts, it can be said that developing flexible shelter units which can adopt themselves to change of needs during life cycle is essential.

2.5 Flexibility and Adaptability in Architecture

Flexibility and adaptability are important tools in architecture as they try to provide environmental, social and economic needs throughout life-cycle. Flexibility and adaptability concepts have been defined in several ways as shown in Table 2.2.

Table 2.2: Flexibility and adaptability concepts (Inani and Kumar, 2012)

Author	Year	Flexibility	Adaptability
Andrew Rabenek David Sheppard, Peter Town	1973	"Flexibility" is proposed against "tight-fit functionalism". The unsuccessful attempts in flexibility are criticized for they may lead to what they call the "fallacy of freedom though control. Flexible housing should be capable of offering "choice" and "personalization".	Adaptability in the housing context refers to the housing units that can be easily altered as the circumstances changed.
	1974	The concept of flexibility deals with the "constructional techniques and services distribution.	Adaptability is related to the "planning and layout" of the building including the sizes of the room and the relation between the rooms.
Herman Hertzberger	1991	In flexible design, "there is no single solution that is preferable to all others; Hertzberger comes with another concept called "polyvalence".	
Steven Groak	1992	Flexibility points to "capability of different physical arrangements".	Adaptability points to the "capability of different social users".
Gerard Macceanor	1998	Flexibility is a "design idea (that leads to) the collapse of traditional layout". "Flexibility does not imply the necessity of endless change and break-down of accepted formula."	Adaptability is a "different way of viewing flexibility" which refers to "transfunctional(ity) and multifunctional(ity)." Maccreanor emphasizes that "most adaptable (buildings) were those not originally planned for flexibility.
Adrian forty	2000	"The incorporation of 'flexibility' into the design allowed architects the illusion of projecting their control over the building into the future, beyond the period of their actual responsibility for it. "The confusion is meaning of flexibility is based on two contradictory roles: "it has been employed to resist functionalism."	
Tatjana Schnieder Jeremy Till	2007	Flexibility in the context of housing is "achieved by altering by altering the physical fabric of building."	Adaptability in the context of housing is "achieved though designing room or units so that they can be used in variety of ways."

(Habraken, 1969) in his book “Variations” expresses how different activities with standart dimension requirements can be arranged alternatively through modular spaces see Figure 2.6. In other words, it shows us how spaces can be designed with flexible approaches. Habraken also uses 30 cm grid system to develop housing plans.

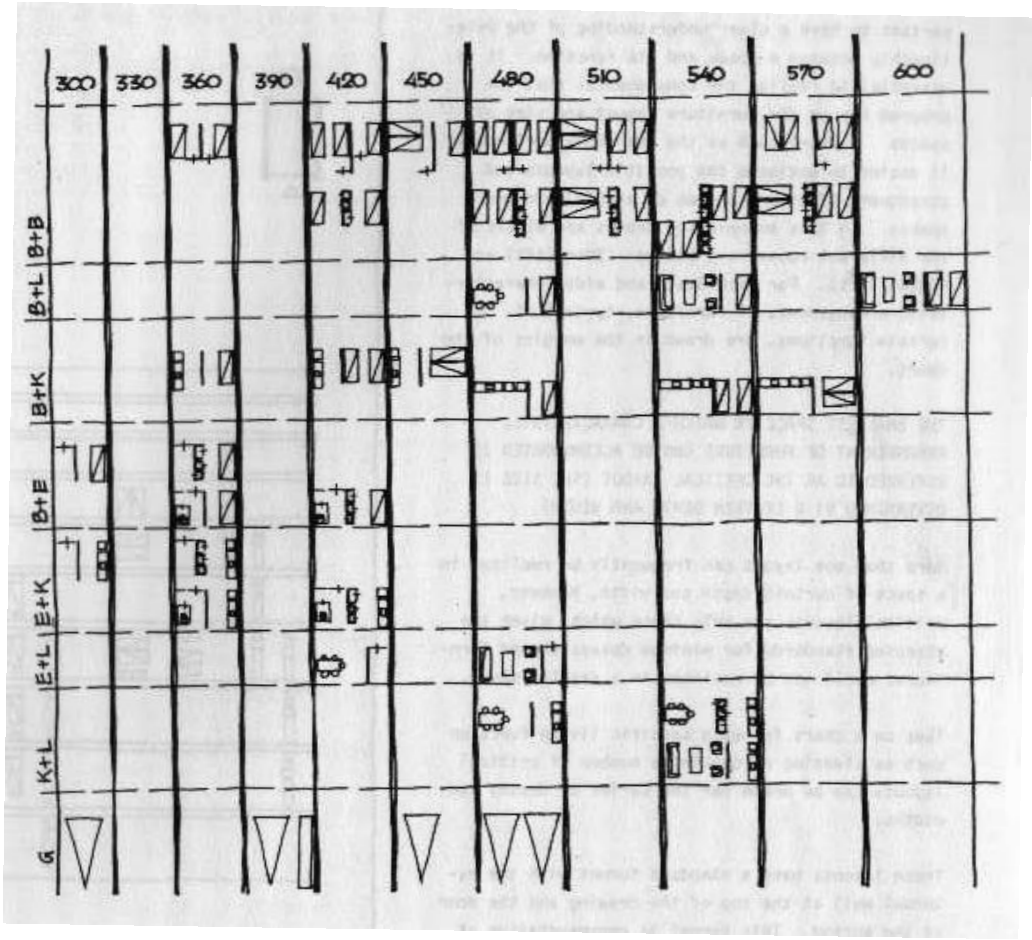


Figure 2.6: Alternative Standart Activities on Modular Dimension Matrice (Habraken and others, 1969)

It may be useful to distinguish the meanings of flexibility, variability, interchangeability andadaptability within the frame of architectural discipline.Yürekli (1983) in his study says; flexibility can be expressed as easy change to fit new conditions. It is the ability to get original shape after going through formal changes. Variability means being able to change.Inter changeability on the other hand is the possibility of substituting for each other, in other words being able of changing places and adaptability means being fit for a new use, need or situation.

CHAPTER 3

DESIGN PRINCIPLESOF REFUGEES CAMPS

It is very important to have a deep understanding of the main principles related to refugee camps design and planning, and learn the standards of them. Site selection, how much liters of water needed per person, the food issues, sanitation, health, supplies and transport, security offices, and education centers are as important as planning of shelter units. All that must be interpreted, in order to achieve progress and develop a unique more efficient.

3.1 Site Selection

Site selection is one of the first discussions that must be well studied by the authorities and the responsible organizations. A lot of considerations must be taken in respect, in order to select the most efficient site. Actually, it's very difficult to find those considerations, because all the suitable options are already taken by the local citizens, or also taken for agricultural activities. One of these considerations is water, a site with no water resource available can't be chosen.

An existed water resource must be located on the chosen site, or even an accessible water source nearby the site. The site shouldn't be selected assuming a groundwater could be exist, the UNHCR has mentioned in "Handbook for Emergencies" that a site should not be selected on the assumption that water can be found merely by drilling, digging, or trucking. Drilling may not be possible or may not provide water in an adequate quality and quantity. No site should be selected where the trucking of water will be required over a long period (UNHCR, 2007).

The objective for camp managers when dealing with water is to provide a sufficient amount of clean drinking water for the persons of concern and to meet their household and other communal needs in such a way that facilitates easy and safe access and is reliable, efficient, cost-effective and environmentally benign (Handbook for Emergencies 2007).

Water distribution becomes an essential aspect in camp layout and design. More specifically, well-planned distribution systems can, according to UNHCR, can help reduce potential sexual and gender-based violence because it is often the women's and children's job to fetch water. As

a general rule of thumb, no shelter should be more than 200 meters or a few minutes' walk away from a water distribution point. Additionally, there should be at least one tap per 80-100 refugees and no more than 200 refugees per hand pump (Huynh, 2015).

Safety must also be taken into consideration and the camp must be secure, the site must be mine free and ideally distant from borders and also far away from the conflicting regions. Also, the area must be studied according to the UN standard. It is recommended that each person should have 45 square meters and no less than 30 square meters in the camp area. Transportation into and out the site must be suitable during all seasons and must be well connected. Climate conditions can also influence the site selection process, topography and soil properties must be considers (UNHCR Emergency Handbook, 2007).

3.2 Site Organization

After the site had been selected, the next step is the arrangement of the wanted amenities done in major view. A studied plan must be set correctly and a well distributed zone along roads network must be considered.

Appropriate routes between all the functions and sectionsis necessary. The installations must be considered for the carrying materials, in order to obtain the maximum performance for the food supplies and medicines, to ensure that the major functions are active. To get highly efficient spatial organization of the temporary housing, and the services, a number of factors should be studied.

- Space required per person and for each installation
- Accessibility of services
- Minimum distance required between facilities and shelters see Table 3.1.
- Cultural habits and social organization of the refugee population (clans and extended families)
- Ethnic and security factors, relationships among different sections/ members of the community, etc.

Cultural and social traditions are a determining factor in ensuring refugee acceptance of the infrastructure and services provided, particularly in regard to housing, sanitation, burial places, etc. However, as the layout that might be preferred by the refugees is not always the one that would allow the most efficient delivery of aid, site planning generally requires compromise solutions that take into account the different points of view (Frontières, 1997).

Table 3.1: Some quantified emergency norms for site planning (Shelter and site planning, 2016)

Camp Settlement Area per person	30 - 45 m^2
Shelter space per person	3.5 m^2
Number of people per water source	250
Number of people per latrine	20
Distance to water-point	15 m max.
Distance to latrine	30 m
Distance between water-point and latrine	100 m
Firebreaks	75 m every 300 m
Distance between two shelters	2 m min

Necessary Installations

Necessary installations are explained in Table 3.2. Some are designated to be centralized:

- Reception center
- Health center
- Hospital
- Meeting place for home-visitors, etc.

Other establishments includes: health centers, latrines, washing areas, etc., should be decentralized. Care must be taken in consideration to make sure that there is plenty of space for such decentralized services in all the camp sub-divisions.

Table 3.2: Facilities needed to be considered (Regattieri, et al., 2015)

Roads and firebreaks
Water supply and sanitation facilities (Defecation areas, latrines, waste disposal pits, washing places, etc.)
Health facilities: health center, health posts, hospital, pharmacy and site for cholera camp.
Meeting place for home-visitors
Nutritional facilities: therapeutic and supplementary feeding centers
Distribution site and storage facilities (in separate locations)
Administrative center, reception area
Other community facilities: market, schools, cemetery, meeting places, etc.

3.3 The Layout of Shelters

The way that asylum is gathered has a significant impact in order to restore the normal life, the utilizing of latrines, water-points and security.

Generally, for management issues the site must be divided into smaller spots. For instance, it could be divided into sectors of 5,000 and sections of 1,000 people. However, the arrangement of such spots must take into consideration the existence of any groups within the population which may be commonly adverse. In order to gather the asylums two major methods are commonly used which are described as, courtyard type clusters and lines and rows clusters.

3.3.1 Courtyard type clusters

The preferred methodology is to set the site into fundamental community units, formed by the asylums and also the community establishments (Washing areas, water-points and latrines) see Figure 3.1. Those necessary fundamentals should be designed to be reached easily, and connected with refugees most needed.

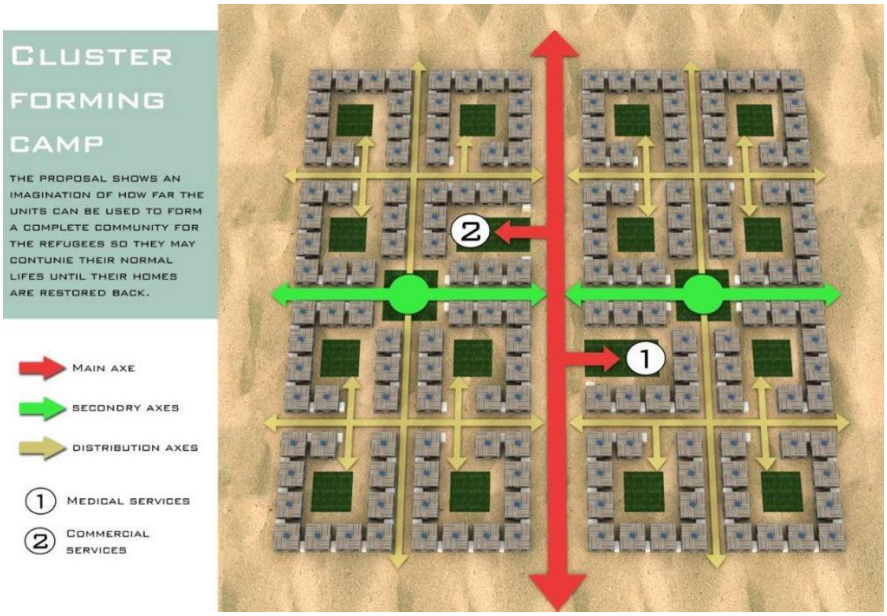


Figure 3.1: Basic community units, formed by the asylums and also the community facilities (Elcharkawi, 2010)

3.3.2 Lines and rows

Is the other possible option to establish, but it's usually a suggested option, because this option prohibits families from their personal area, and enlarges the range to latrines and water-points. This option is most often selected just because it is fast and effective in the sudden moments and it overcome with the huge influx of refugees see Figure 3.2.

Figure 3.2: KILIS refugee's camp, Photo by Tobias Hutzler, for The New York Times Magazine (McClelland, 2014)

In case of having an existed asylum had been settled randomly, as in most cases, without having any site planning, the goal must be set to improve the current situation. Fortunately, in many cases the site could be enhanced without rearrange all the shelters. A better organization of facilities, improving access to all sections of the camp, and carefully planning sections for new arrivals will decrease health risks and improve camp management.

An action of reorganization of the whole site must be taken, when refugee's health is in danger. Or if there is a serious fear of fire, hurricane, etc. For example, in 1993 a reorganization of the shelters happened in Rawandan camps, to protect the refugees against expected fire. The option of moving to another site could be proposed, when facing a situation like paucity of water in the site, or insecurity, etc. But moving the camps could accrue a physical and social problem for the refugees, in order to avoid those problems everything must be calculated carefully in advanced.

3.4 Shelter Provision

The purpose of establishing shelters is to protect the refugees from the outside environmental factors, and also to provide a privacy space for families, to give them the feel of secure. Shelters must be existed in every refugee emergency, shelters affected by the type, design, and also the duration of the camps, all of those factors determine what type of shelter should be formed. (UNHCR, 2007).

Nonetheless, the major standards could likewise be concluded. It is best to utilize appropriate nearby materials where accessible. Special emergency shelters (e.g. tents) and pre-fabricated units have not yet proven practical because of their high cost and the problems of transporting them. It is also difficult to persuade refugees to accept something which is not within their cultural traditions. However, some types of prefabricated shelter are still being tested and may be suitable for use in the first weeks of an emergency.

Standard shelter space per person recommended in emergency is 3.5m² that is also could be changed according to the different culture's needs. In order to provide temporary shelters, there are several suggestions could be considered: The most common solution to construct temporary shelters is to let the refugees themselves make them, by local materials distributed by the

responsible. In case of lack of local materials, tents are recommended to use for temporary short time. Public buildings "schools" may help, however. They are not recommended for large numbers, only work as temporary solution. After the emergency period has passed, the temporary shelters must be replaced with the permanent shelters (UNHCR, 2007).

3.5 Health Facilities

It is imperative that site planning is completed almost immediately in order to reduce health constraints, provide appropriate facilities and prevent the influx of refugees. In order to protect refugees from the surroundings, shelters should be provided quickly, accompanied by compulsory health and nutrition facilities, installation of water supply, latrines, etc. There are two likely scenarios that relief agencies frequently encounter, the first is that the camp is established in advance and the refugee population has settled quickly before relief agencies arrive. The second case is where, the relief agencies appear before the refugees have settled, allowing them to have more control of the situation. An example of this can be in the case of relocation or transfer of refugees from one camp to another (UNHCR, 2007).

Weak decisions in the early phase may cause an unsteady situation with regards to camp organization, with knowing health concerns, therefore strict action must be taken in order to improve the site and its facilities. For instance, to avoid any hindrances such as congestion in the near future, site extension must be well thought out from the beginning. There has always been a debate whether funds should be used to sustain local communities who host refugees, or to establish refugee camps (UNHCR, 2007).

3.6 General Management of Camps and Refugee Settlements

Site planning must make sure to achieve reasonable space arrangement, as well as providing temporary housing and the facilities essential for passing on necessary goods and services. In order to accomplish this, proper management by specialists is required from different departments being; sanitation, geology, construction, etc. Coordination from the beginning is necessary between all agencies involved as well as among various sectors of activity. Especially in a crisis when time is critical.

UNHCR is responsible for supervision of refugee site planning, however other agencies take control as a result of them being not always readily available in regard to an internally displaced settlement. For example, PDMA was responsible for the Jalazoi camp. Health agencies must make sure that particular protocols that can a have a huge impact on health hazards are followed, even though they may not necessarily be involved in coordinating sites. It is therefore obligatory to have comprehensive knowledge of all fundamental principles in site planning (Express Tribune, 2012).

As clarified over, the possibilities in with respect to site arranging depend exclusively on which of the two refugee situations defined will be encountered. Generally, while planners may be undertaking harsh situations, refugees could settle down on a site. It is sometimes preferable to move the people to another site as the main concern is to upgrade or renovate the existing site. Following proper guidelines, it is important to work out the most suitable site in advance. High density camps have a higher chance for disease transmission, as well as fire and safety concerns therefore they must be prevented (UNHCR, 1996).

Likewise, alleged temporary camps like the Palestine refugee camps which have been open since the year 1947 develop due to short-term site planning, therefore this must be avoided. In case of an increase in population, supplies must be granted for any likelihood of expanding the site. It is advisable to have multiple smaller camps instead of a single large camp as they are known to be self-supporting and easier to handle. Unfortunately, this may not be a possibility because of the massive inflow of refugees over the years. Since 1993-1994, refugee camps have been in operation in Rwanda and Burundi. Before as well as during the planning stages, refugees must participate as well as confer with the authorities and their social system of governance and ideas should be considered whenever possible (UNHCR, 1996).

Camp, and integration into a local population are two main types of refugee settlements, they each individually have advantages and disadvantages. The advantages of camp are that it provides protection and asylum, which is important at that point in time. It is also easier to estimate population numbers and the needs of refugees as well as monitor their health status, and it more appropriate for temporary situations. Repatriation will be easier to plan, as well as permitting visibility and advocacy. However, on the contrary, there is an increased risk of

outbreaks of communicable diseases due to overcrowding; this poses a colossal issue for the organizers as well as the displaced people. There may also be problems with degradation of the surrounding environment, security problems, lack of autonomy, and dependence on external aid. Consequences of social isolation need to be conducted expertly as the consequences may be remorseful (UNHCR Emergency Handbook, 2007).

When it comes to integration into a local population, the benefits are that it gives easy access to alternative foods, jobs etc. as well as helping refugees to have mobility. It provides the option of refugees to have access to existing facilities such as water and health, while also favoring refugee survival strategies. Additionally, it improves integration into the future by enhancing reconstruction of social/economic life. There can also be some disadvantages to integration, one being that it is difficult to reach the population, leading to problems in monitoring health needs. Knowledge of the local situation is required in order to be able to implement such relief programs. It may cause possible tension between local communities and the refugees therefore increasing the risk of destabilizing the local community.

Since each refugee situation is relatively different, in most cases, the health agencies do not partake in determining which of the two options to select. A portion of the main considerations that add to the last determination are the quantity of refugees, the limit for the local community to assimilate them, the ethnic and cultural links between the refugees and the local communities, and the political and military situation. The bond among refugees and the local people is the principle factor leading the decision, in practice. In some cases, relief programs especially food aid, may play a role in attracting refugees into a camp situation, even though integration would be a more superior option (UNHCR Emergency Handbook, 2007).

In case of a disaster, whether natural or man-made, shelter is the only thing that matters. Immediate response is essential to assess the provisions already made and deliver material for temporary shelters. With the help of either local materials or those allocated by agencies, the most common solution is to build temporary shelters utilizing the refugees themselves. Tents are overpriced, therefore may be handy for only a limited period of time. Plastic sheeting can also be used to construct temporary shelters for protection. A temporary solution such as state

premises, like schools are a temporary solution however they are limited to a certain number for people and for a limited amount of time.

Shortly after the emergency phase is over, temporary shelters should no longer be used and more permanent shelters should be designed for the refugees. During the course of the shelter building programs, several limitations need to be taken into consideration. The renovation and restoration methods can be very expensive as well as quite time consuming. Extreme measures are sometimes taken in order to make the programs simpler in terms of management; this is partly due to the vast assortment of choices for constructing shelters at times, local administration may obstruct refugees from staying for a longer duration and this may result conflict, as they are not in favor of permanent housing (semi). As a result, the job is rather unique and requires proficiency. Using local material is greatly endorsed however due to the fact that harm may be caused to the environment through deforestation; its accessibility might be a hindrance. Shelter building is crucial for surviving the conditions, in countries like Afghanistan or European countries due to the low temperatures recorded in the winters. It still remains a very complicated issue to handle in a crisis situation even though several considerations have been taken into account for example, installation of heaters and use of specialized winter tents (UNHCR, 2007).

3.7 Types of Camps

The chief necessity for people to have when a natural disaster occurs is a roof over their head. Disaster relief groups make certain that all victims have shelter. After the basic need of shelter has been achieved, more creative ways can be invented to provide comfort. Quick and easy to assemble self-build homes, as well as affordable shelters are available globally. Camps with such shelters are subdivided into four types: spontaneous; collective; transit; and formal camps. Spontaneous camps are set up locality for a temporary period and are used in case of emergency, like floods and earthquakes. Formal camps usually accommodate refugees and IDP's and they are built for a longer period of time, between four to six months. Collective camps are set up in existing buildings, typically public, in case of an emergency or an immediate response situation. Whenever there is a fire, rain or other disasters, it has been observed over recent years, how people are evacuated from public schools in the neighborhood. Camps are also a temporary setup where people in dangerous situations stay together for a particular period of time. When

a certain group of people are in the process of moving to a final destination, transit camps are set up for them. These usually happen in the outskirts of the city, away from all facilities (UNHCR Emergency Handbook, 2007).

This thesis will be discussing the formal camps type, which include the two main shelters types, UNHCR's canvas tents and Shipping Containers for more sustain and efficient.

UNHCR's canvas tents:

These types of tents are usually designed as a temporary shelters, unfortunately they are the most common used in formal refugee camps. They provide more space than the lightweight shelters; also, they are made from 50 percent cotton and 50 percent polyester canvas, they are more waterproof and durable. But they aren't very livable, have no electric, no partitions, and no insulation. See Figure 3.3. UNHCR pays manufacturers in India and Pakistan a considerable amount for one of these (UNHCR, 2007).

(a) Transit camp

(b) Displaced Syrian children stand in muddy water after heavy rains in the Bab Al-Salama

Figure 3.3: Camps situation (Al-Halabi, 2014)

A lot of refugee camps use UNHCR's canvas tents; include bab al-salam camp Syrian Turkish border, al Zaatari camp Jordan, and Dagahaley refugee camp Kenya see Figure 3.4.

Figure 3.4: Upper view of canvas tents in Al Zaatari refugee camp (Malas, 2014)

Shipping Containers

As emergency housing for natural disaster and war victims, over the years, recycled shipping containers have been utilized. The insoluble exterior in combination with the solid structure makes it an ideal shelter for natural disasters, earthquakes and hurricanes see Figure 3.5. They are also used in designing attractive modular homes apart from the fact that they are frequently available and structurally-sound. Disaster relief tents are water resistant and give victim a sense of privacy as well as being portable, easy-to-install structures that use strong frames and high-quality fabrics. A family or group of people can divide tents to create separate rooms (living, bed and toilet) at their convenience as well as having sufficient space. Some tents are adept to resisting severe weather conditions as well certain natural disasters, depending on the groundwork of techniques and materials applied during the building phase. In cases of particular

locations having seasonal monsoon rains or snowfall, it is suitable for people who enjoy extreme weather conditions (Containerauction, 2015).

Figure 3.5: Two different views for shipping containers (Containerauction, 2015)

Tents are being recently replaces by shipping containers in AlZaatari refugee camp and many old and existing camps which show the efficiency sustainability of the shipping containers.

There are also camps designed as shipping containers camps for examples (Kilis in Turkey, Azraq in Jordan, Calais, France) see Figure 3.6.

Figure 3.6: Perspective view for Azraq Refugee camp in Jordan (McClelland, 2014)

Table 3.3 below shows the comparison between canvas tents and shipping containers in order to find the power and weak points in each. This table shows the necessity to create a shelter

Table 3.3: Shipping containers and canvas tents comparison

	Canvas Tents	Shipping Containers
Expenses	less	More
Time to establish	more	No time
durability	Less	Much more
Weather resistance	Bad	Good
Water resistance	Bad	Good
Insulation	Bad	Bad

That gather all the advantages of both of the most common kinds and put them in one shelter (Cheap, Durable, no time to establish, Weather and Water resistance, Good insulation, and livable). This is exactly what the case study will accomplish. There are for sure more type of shelters could be a good reference among the thesis, but they are less important than the two main ones studied above.

3.8 Sustainable Shelter Design

In this part of research' sustainable materials that can be used for shelters will be examined. Shelters built by green light materials and or recycled materials can be evaluated as durable and sustainable structures. Sustainable building design often focuses on constructing houses that are less polluting or sustainable material that are low in carbon. In green or sustainable construction, engineers seek to design and incorporate shelters that are eco-friendly, sustainable, cheap, and long-lasting. The most important sections of a house shelter are walls and the roofs, which in sustainable building, must provide high-quality houses at affordable and eco-friendly manner (Sutton, Black &Walker, 2011). As the construction engineering reforms towards the realization of the need to protect the environment and maintain the natural biodiversity of the environment, the need to find solution to the conventional construction materials that were not eco-friendly

has arisen. A green shelter is a term that describes the construction material that meets the environmental and health standards through its Life Cycle Analysis (Mills et al, 2012). All materials meant to promote the construction of sustainable or green buildings must remain relatively harmless to the environment in several years of their survival.

3.8.1 Sample for sustainable shelter design

Elcharkawi's project which is developed as flexible short-term refugee's shelter is worth to examine. In this project rice straws are used to make panels. Rice straws are costless and are easy to find in most of the places of world near water sources. They can be obtained by using the pressure method see Figure 3.7. These panels are very resistant to huge impacts and have a very good insulation ability (Elcharkawi, 2010).

Figure 3.7: Rice straw as selected material for shelters (Elcharkawi, 2010)

By combining two rice panel with one insulation foam board in the middle, and paint the outside layers by fire resistant's polish see Figure 3.8, and 3.9. A very efficient wall with high heat and fire resistant shelters, and also still all the materials used in this method are extremely cheap and sustainable.

Figure 3.8: Steps in order to create the shelter's walls (Elcharkawi, 2010)

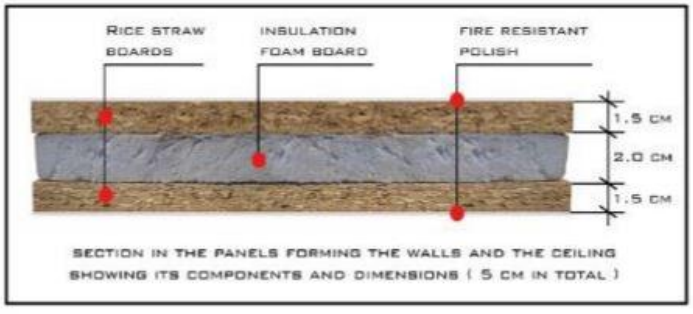


Figure 3.9: Section for the insulation layers (Elcharkawi, 2010)

One of the important properties of this project is that the units can easily be constructed in a short time see Figure 3.10, and 3.11by the refugees themselves.

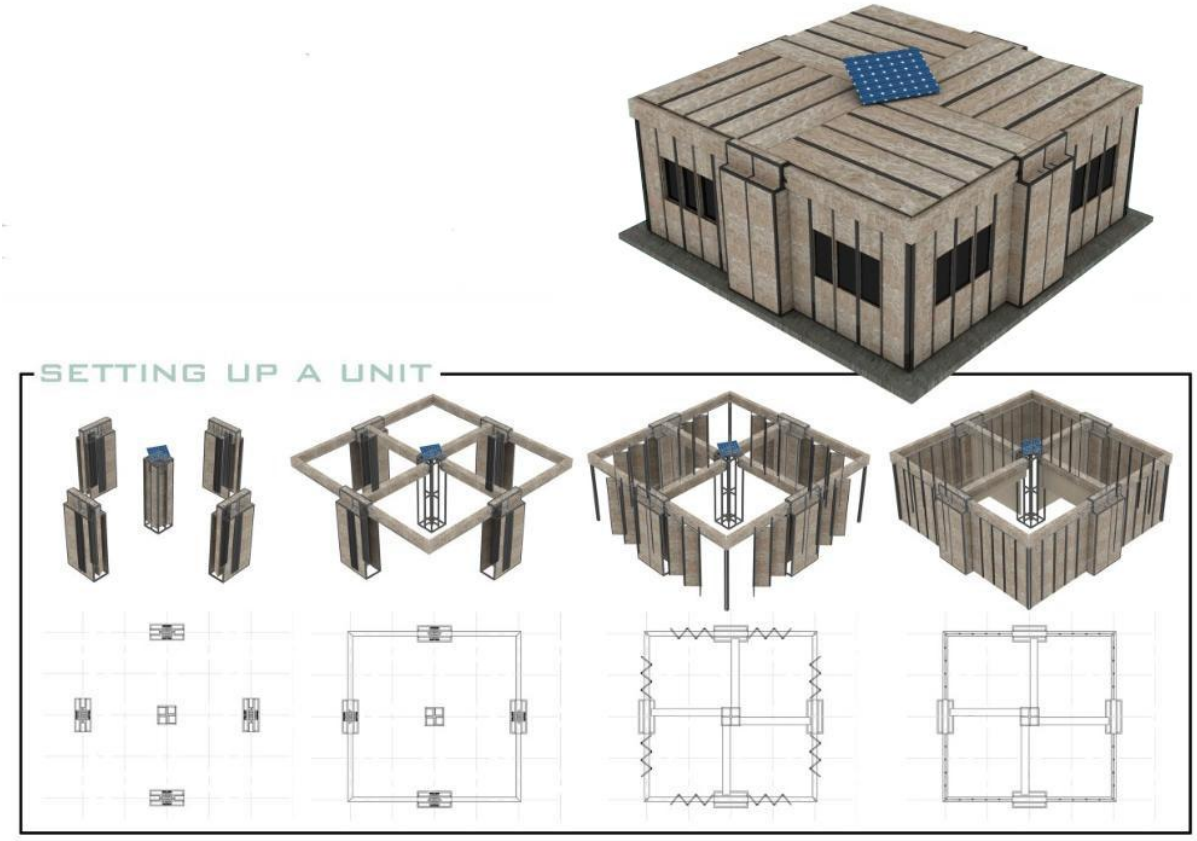


Figure 3.10: Setting of shelter unit with prefabricated building elements(Elcharkawi, 2010)

Figure 3.11: Shelter perspective (Elcharkawi, 2010)

The shelter is designed for temporary camps. Therefore they don't have kitchens. But the same units can be used as health and education premises see Figure 3.12.

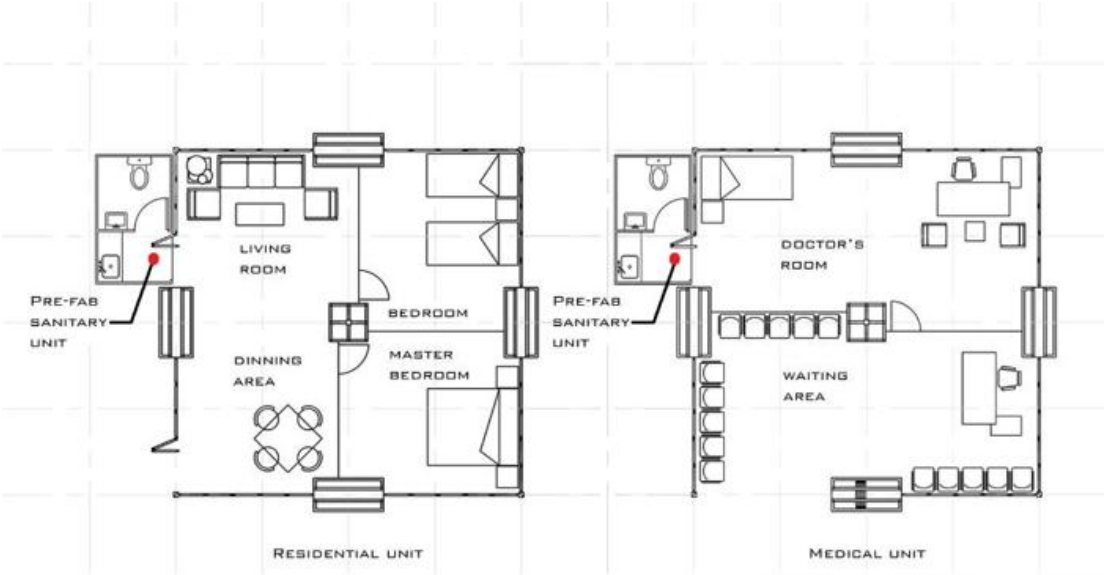


Figure 3.12: Shelter alternative plans as residential and medical units

The study also considers ventilation. With a detail on the ceiling which can be opened and closed, hot air gets out of the shelters and reserve the cool air in see Figure 3.13.

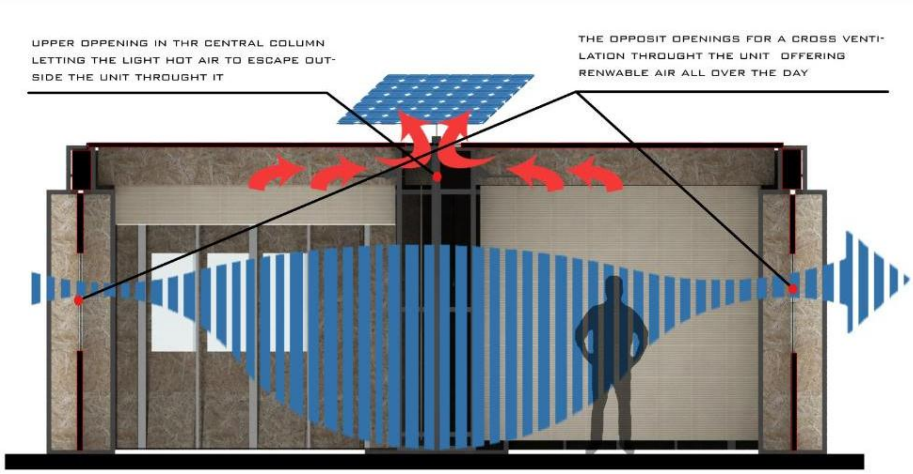


Figure 3.13: Ventilation Diagram (Elcharkawi, 2010)

The material of the glass made which called "lexan sheet" play a very important role in the insulation process, and because of the voids between its layers Figure 3.14 day light passes in while radiant heat transfer is prevented. It's also acts as noise and sound insulator.

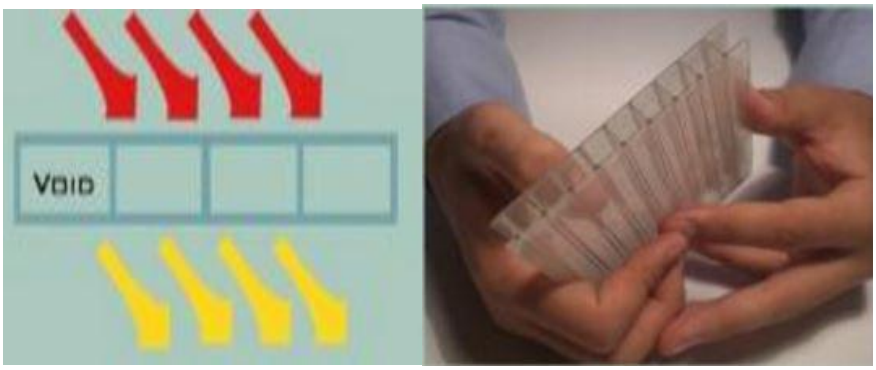


Figure 3.14: Lexan sheet detail (Elcharkawi, 2010)

All of those materials mentioned above are efficient, cheap, easy to use, and can be accepted as sustainable materials.

3.9 Other Types of Shelters

Shelter canopies are frequently mistaken as just being a box structure made using an overhead roof and four poles see Figure 3.15. However, it can have added features like windows, doors and protective lining that can shield people from outside elements like water and bugs. These canopies can be used quickly when required and they are easily moveable. They are used as tem can be used as temporary housing however modifications can be done to them to make them feel like home, for example use of generators, lights, beds, tables and other amenities (Hexayurt project, 2016).

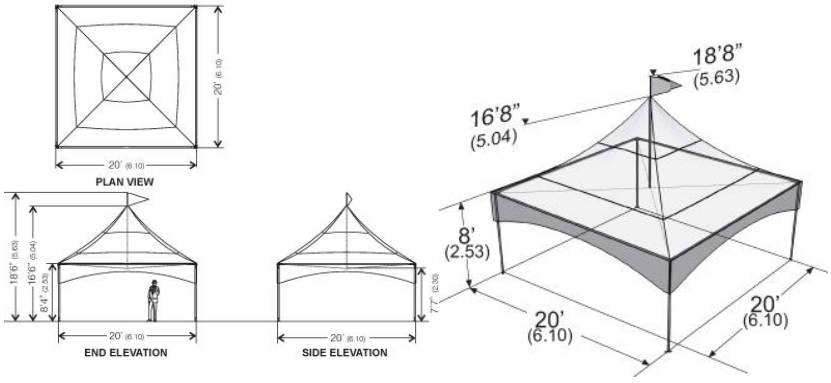


Figure 3.15: Shelter canopies (Hexayurt project, 2016)

Foldable shelters can without difficulty be folded into homes of different shapes and sizes and can easily be refolded for easy transport and storage. These are affordable in terms of the cost involved, compared to other shelters and they can accommodate four or more people. Foldable homes are typically made from polypropylene; it is considered one of the most popular choices for natural disaster victims compared to the others due to its unique folding design see Figure 3.16 and 3.17.

Temporary homes are portable, long-lasting and protections against weather and other elements; they are often produced using high quality plastic sheets. Plastic sheets are can be used to reinforce existing houses, to create community shelters, single family homes, or latrines (Igreenspot, 2014).

Figure 3.16: Foldable shelter (Igreenspot, 2014)

Figure 3.17: Foldable shelter details (Igreenspot, 2014)

Sandbags can create robust and artistic structures that can resist floods, earthquakes and hurricanes due to the multiple characteristic of the sandbags. They can be used as temporary shelters or transformed into self-sustaining houses, much like the abode-style homes. A popular example of sandbag shelters is frequently seen around borders and exit points of cities; they are used as check points for forces army.

Hexayurt homes provide a sustainable, eco-friendly and economical shelter for refugees. It is a geometrical shaped shelter painted and personalized to individual preference using OSB, hexacomb cardboard, sheets of plywood, coroplast and other constructional material. They have the ability to endure various climates and weather conditions over a long period of time; they are also spacious for windows, furniture, doors and dividers see Figure 3.18 and 3.19.

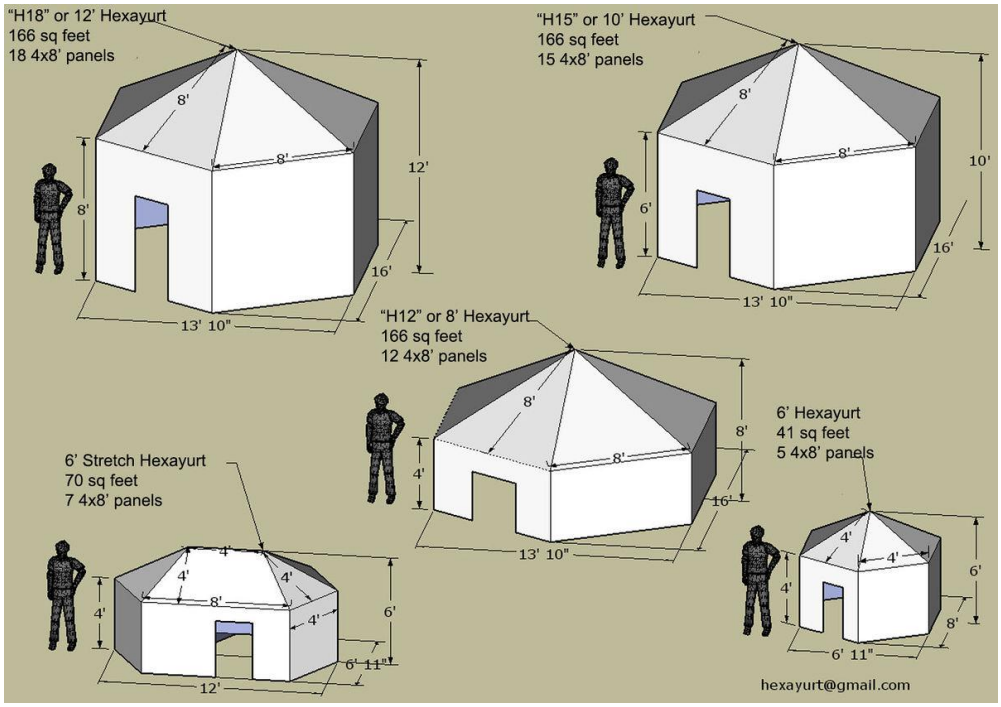


Figure 3.18: Hexayurt homes illustration (Hexayut project, 2015)

Figure 3.19: Hexayurt homes (McCalla, 2016)

Bamboo houses are the most preferred form of shelter for victims that frequently end up in similar circumstances caused by the disaster. Bamboo has half the tensile strength of steel and double the compression strength of concrete as well as being a very flexible and sturdy material. These houses have the power to withstand deadly earthquakes, typhoons and other natural disasters if suitable methods are applied in the construction phase. Due to the fact that bamboo is readily available in Asian countries, this makes the shelters additionally economical see Figure 3.20 and 3.21.

Figure 3.20: Interior of a bamboo house in Thailand (Bamboocreasian, 2014)

Figure 3.21: Abamboohousein Thailand (Bamboocreasian, 2014)

Inter shelters are dome shaped homes, made from a fireproof structure and fiberglass composite mixture. They can effortlessly be broken down, reconstructed and relocated for numerous shelter needs and they can provide accommodation for an entire family. They are able to withstand natural disasters and extreme weather (Category 4 hurricane, an 8.5 magnitude earthquake) and each dome weighs a significant amount of pounds. The concrete canvas developed a structure that only needs water and air to expand, in an effort to construct permanent housing during a disaster see Figure 3.22 (Bamboocreasian, 2014).

Figure 3.22: Intershelters (Geiger, 2014)

This portable shelter is entirely waterproof, chemically resistant and fireproof and it is made of cement-soaked cloth that expands and hardens in one day. There are multiple layout arrangements that can satisfy the needs of the occupant as well as being able to cut doors and windows for ventilation. These shelters have the affinity to be sustainable in varied locations and for this reason they are frequently found in military camps.

The stress of living in a refugee camp can on occasion be highly unstable. Stronger and lightweight shelters can help refugees as well as host countries and new advanced technology allowed this to be accomplished. This expertise provides longer lasting shelters, between 6 months and a year, as well as leading to economical results (Geiger, 2014).

3.10 Green Methods and Techniques

Camps are used in order to assess the initial emergency Situation and can support refugees for some time (Huynh, 2015). Refugee camps in most of the time are designed as temporary settlements, in fact these camps exist for quite long time. This gives us a clear answer of why always refugee camps are not sufficient or not even enough for the refugees needs.
Lack of planning, lack of budget, and lack of time needed to contain the crisis and the huge number of refugees, are always deterring to establish a good healthy camp. The purpose of this part of thesis is to study and gather green methods by looking deeper in green materials, green walls, and also by implementing solar system that will provide the camps the energy needed, adding to other affecting techniques, find smart solution for water, also fine some activities to let the refugees become very active part of camps productivity.

In this paragraph the whole methods are proposed to be used in the green refugee camps will be explained in practical way in order to be approved by any sponsored organization that could hold the project, all the methods must be studied, easy to establish, efficiency, and cheap.

There are two kinds of Green methods which are studies in this thesis research, first one is psychological green methods, and the second one is physical green methods.

3.10.1 Psychological Green Methods

It's always messing in any refugees camps that it's not only the shelters and the location are the main goals, but there is also a very important one which is the psychological situations of the refugees and displaced people. It is just injustice not to notice their inside needs. Most of the refugees are not just running from dead, they lost their children; they lost their houses, their memories bombed with their homes.

They in so many cases suffered more than so many people, because they felt the fear and panic, they felt how to lose someone forever, those are very serious problems.

That's why most of the refugees are depending only on the organizations to provide them with all their needs including almost everything (food, water, clothes, etc.).

As a GRC (Green Refugees Camp) the goal is to let everything be productive and less consuming including the refugees themselves, but when they first arrived they came with depression and sadness that prevent them from doing anything else except being positive and ask only for help, it's very crucial that they prepaid their self to a condition the we also helped them to be inactive people by treating as burden and prisoners.

In this GRC the goal is to give them chance to be active and manage their lives as they used to. That can be done by healing the depression and other hard psychological issues, by establish a psychotherapeutics centers in each region of the GRC to treat the serious psychological problems.

After the person had been recuperated and be able to work and be more active, specialists take them and prepare them to work according their knowledge and their certificates, then Employ them in positions in the camps (accountants, engineers, architects, Doctors….etc.). There are plenty of positions because in each region of the GRC there are more than sixteen different buildings, on each building there could be between (100 to 300) employees needed according to the function of each building.

By employing the refugees, they will feel more productive, also the income from those positions will cover their needs, it's also better for the hosting organizations to employ them instead of bring the employees from outside the camps.

Another kind of the physiological method is the common spaces which will give the sense of the community, and let the refugees meet each other and communicate with each other. This spaces are very important for the refugees to forget that they are refugees and change their physiological status to be more positive and friendly.

3.10.2 Humanitarian Green Methods

This kind of methods is related to the human behavior and attitude that allow the refugees to make their own business and trades. For example, if planting area with the rights of using or renting is given to each shelter, this may encourage refugees to make their business. They can decide whether they want to work and sell what they plant and harvest, or to out rent it. In both ways they can make income. But to consider that in some cases some of the refugees got serious injured from the war the run from, or some of them are already working inside the GRC as an employee as a full-time job. That's why the out-rent option should be open.

In order to let everything under control the Agriculture Institution must be established to control the prices, give help and educate the refugees whom want to plant, arrange and recommend each shelter what to plant to make the variation needed to fulfill the GRC needed of the vegetables and to give them the advantages of making vegetables exchanges, and also distribute the equipment for the first time for each owner.

The impact of this whole process is astonishing, because it's not only provide the shelter by food, this process creates opportunities for them by various option and let them make an income in many ways (sell the vegetables, out rent the planting area, or even exchange the vegetables depends on estimated prices for each kind of vegetable determined by the Agriculture institute), and also give them the feel of proud instead of depression and sadness (UNHCR, 2015).

3.10.3 Physical Methods

A lot of modification can be made physically in order to find and use the most efficient and low price methods and materials that let the GRC to reach its goals. Some of these modifications are as follows.

Reuse of water: Reuse the cleaning water after filtering it on irrigation purposes and others. Cleaning water means the water used to clean dishes, shower water, the ablutions water, etc. Taking the water used in shower as a study for how much is the average of water wasted per day by 5 refugees living in a shelter per shower. Showers used to use up to 5 gallons of water per minute. Water-saving shower heads produce about 2 gallons per minute (USGS, nd).

Let's assume that each shower takes 10 minutes, that gives the following,(2 Gallons =7.6 L) flow per minutes which means that each person consumes (7.6*10) 76 liter per person per shower. If five persons living in one shelter take shower every day that means (76*5) 380 Liter only for taking shower per day per one shelter. Many green techniques can be used in order to reduce this waste. Tanks can be provided as simple water filters to clean the water to be used in irrigation, toilet flush, cleaning houses, etc. see Figure 3.23 for simple water filter.

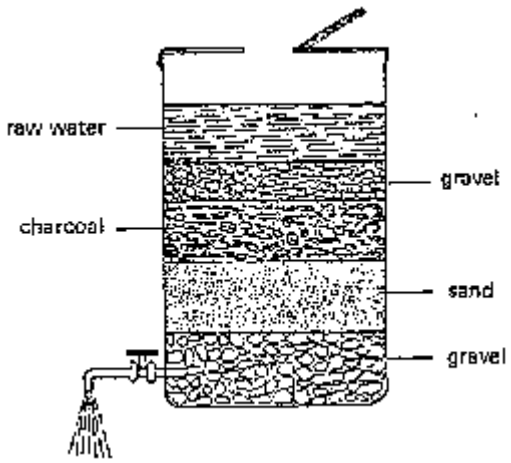


Figure 3.23: Simple water filter (Heber, 1985)

Toilet flushes consume 1.6 Gallon per flush (USGS, nd), if this method achieved, for a camp of 150.000 refugees savings will be around 9.5 million liter per day. This is an enormous saving of water, and no more consuming for the drinking water. This method will also cover the total amount of water needed for the irrigation purposes.

Solar Panels: Solar panels are also known as photovoltaic or PV systems. The panels use the sun as a renewable source of energy in order to convert the sun heat into electric, this method is pollution-free, which means that this process doesn't produce any carbon emission, unlike the other fuel methods see Figure 3.24.

"PV works best in an energy-efficient building. So, adding insulation and energy-efficient lighting, appliances, and windows is a good idea, to reduce your home’s overall electricity use before you install a PV system."(US. Department of energy, 2012).

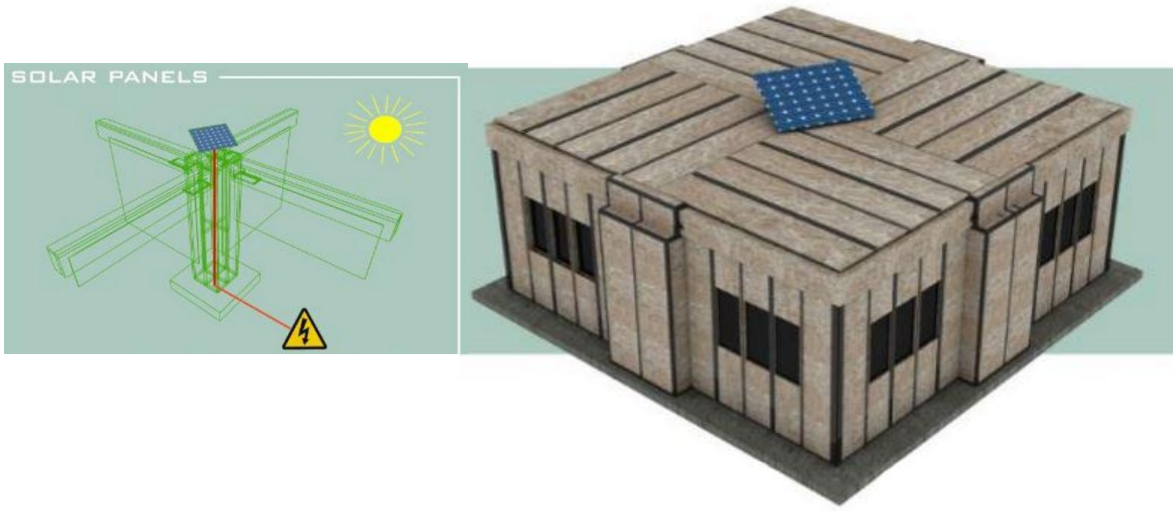


Figure 3.24: Perspective for solar Power over the shelter (Elcharkawi, 2010)

The photon of the sunlight hit the semi-conductive material, such as carbon so its electrons are released and produce electricity. Carbon will be used instead of Silicon because it is less expensive and eco-friendly see Figure 3.25.

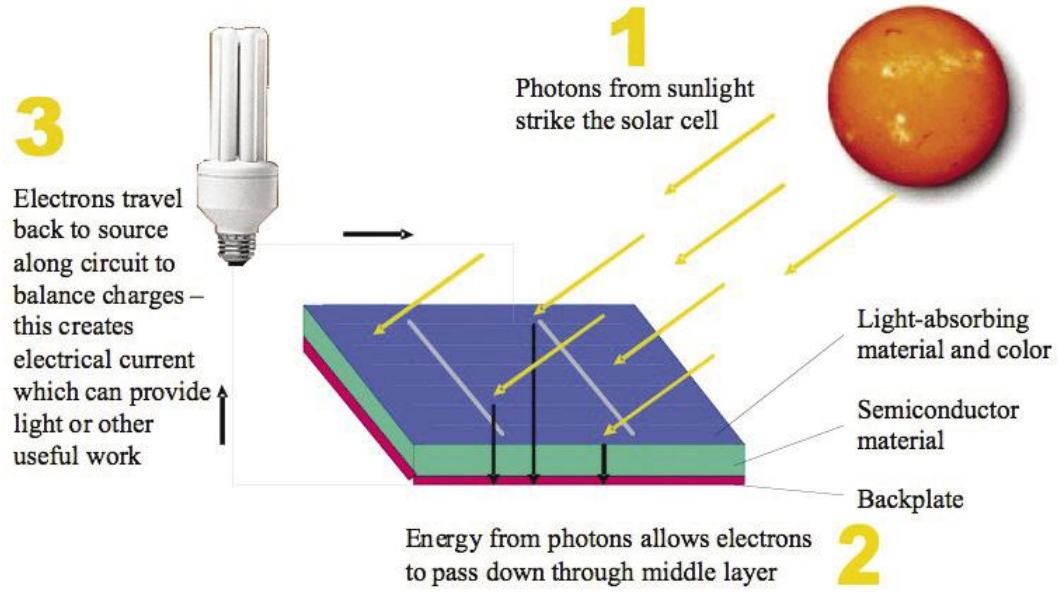


Figure 3.25: Drawing of how solar system works (Maczulak, 2009)

Photovoltaic of dimensions 60*60 cm, is enough to meet the needs of artificial light usage (40 watt) for a 64 m^2shelters (Survivals Columns, 2010).

Conversion of urine to electricity: This method is more modern than the other methods mentioned. It converts urine to electricity, and that happened with very simple techniques and low-price material for making the converter see Figure 3.26. The idea is about:

- Urine is put into an electrolytic cell, which separates out the hydrogen.
- The hydrogen enters a water filter for purification, which then gets pushed into a gas cylinder.
- The gas cylinder pushes hydrogen into a cylinder of liquid borax, which is used to remove the moisture from the hydrogen.
- This purified hydrogen gas is pushed into the generator. (Collective evolution, 2013).

This invention produce the electricity from urine only, were made by three schoolgirls from Nigeria. In 2012 according to the girls, with this device they could achieve for each liter of urine 6 hours of electricity lighting a house normal lamp.

Figure 3.26: Simple machine of urine converter (Maker Faire Africa, 2016)

Figure 3.26 above shows the simple and cheap tools used in order to create the first prototype of their great invention.

Another invention with the same principle but more advanced and efficient is invented in Ohio University called “pee power” wastewater remediation technology. Urine-powered cars, homes and personal electronic devices could be available in six months with new technology developed by scientists from Ohio University. Using a nickel-based electrode, the scientists can create large amounts of cheap hydrogen from urine that could be burned or used in fuel cells. One cow can provide enough energy to supply hot water for 19 houses," said Gerardine Botte, a professor at Ohio University developing the technology. "Soldiers in the field could carry their own fuel. (NBC NEWS, 2009).

This invention also relies on an element that is hard to store, manufacture, and transport to be used economically which is hydrogen. According to a professor at Ohio University says: saving hydrogen gas needs low temperature, and high pressure. New nonmaterial with high surface areas can absorb hydrogen, but have yet to be produced on a commercial scale (Maczulak, 2009).

Chemically binding hydrogen to other elements, like oxygen to create water, makes it easier to store and transport, but releasing the hydrogen when it's needed usually requires financially prohibitive amounts of electricity.

By attaching hydrogen to another element, nitrogen, Botte and her colleagues realized that they can store hydrogen without the exotic environmental conditions, and then release it with less electricity, 0.037 Volts instead of the 1.23 Volts needed for water.
As DarshanGoswami, M.S., P.E. said: Hydrogen has the potential to do for the energy revolution what the computer and the Internet have done for the information revolution. Fuel cells are considered the “microchip of the hydrogen age (NBC NEWS, 2009).

Use of food waste as soil nutrients: Turning the food into compost can be used in the special planting areas in the GRC. This method reduces the food wasted and also make organic compost to the plant instead of buying them. Compost helps the soil to obtain organic matter content. Composting also give the soil the moisturizing and notarizing, it is also feed the microorganisms that live in the soil. There are two categories of wasted food, will be collected in order to produce the compost, carbon materials and nitrogen materials.

Carbon Materials (Brown Materials) are the dead or dry ones, including sawdust, hay, cardboard, dried and crushed leaves, paper, thick stems(flowers stalks, corn, broccoli), and more. Nitrogen Materials (Green Materials):are the still wet or live ones. Including anything rotting, vegetative garden debris, weeds, raw manure, and more. To collect those materials easily and efficiently the refugees must separate those materials, each material in its container. This must be the refugees responsible to separate the waste, then each evening those containers emptied in trucks then the converting process will be made in special places under specialists' control. Then after the compost is ready, the agriculture institution will divide the compost to the refugees whom planting their planting areas.

The above methods can be used in the GRC in order to make the camps really Green, and only depends on the renewable resources like sun and urine and get the maximum use of the waste materials like the water and food and reuse them on other awesome proposes. Instead of using the unnecessary reliance on oil and fossil fuels. Also planting their needs of fruit and vegetables instead of buying, that also will turn the refugees from burden people into productive and responsible people. With all those methods together plus the increasing the refugees awareness, the GRC will reach its goals, and also be able to be established in any place in the word by being dependable and adaptable.

CHAPTER 4

CASE STUDY

4.1 Methodology

After the literature review, in order to develop flexible shelter units which will be used as a long term residential unit in refugee's camps, the following steps are considered. Firstly 30 cm grid system has been preferred for unit plans as it's the recommended grid system for housing plans. Secondly modular prefabricated building materials are chosen. Thirdly modular which is mentioned before shelter units according to family sizes are studied. Fourthly the modular shelter units are combined around courtyards to form clusters. Courtyards are preferred as they provide a good social communication among people. Courtyards are also efficient spaces in terms of climatic conditions. Particularly in hot climates where during day time shaded areas are needed. They also prevent spaces from heavy dusty wind. At the same time courtyards are good barriers for heavy cold winds during winter time.

4.2 Modular Prefabricated Materials for Flexible Shelter Units

The chosen prefabricated materials for flexible shelter units are mainly studied as; modular steel structural system, wall panels and roof panels. The typical system for shelter units is shown in Figure 4.1. The composite roof panels consist of metal plate and heat insulation layers. Composite wall panels consist of compressed rice straw and insulation layers.

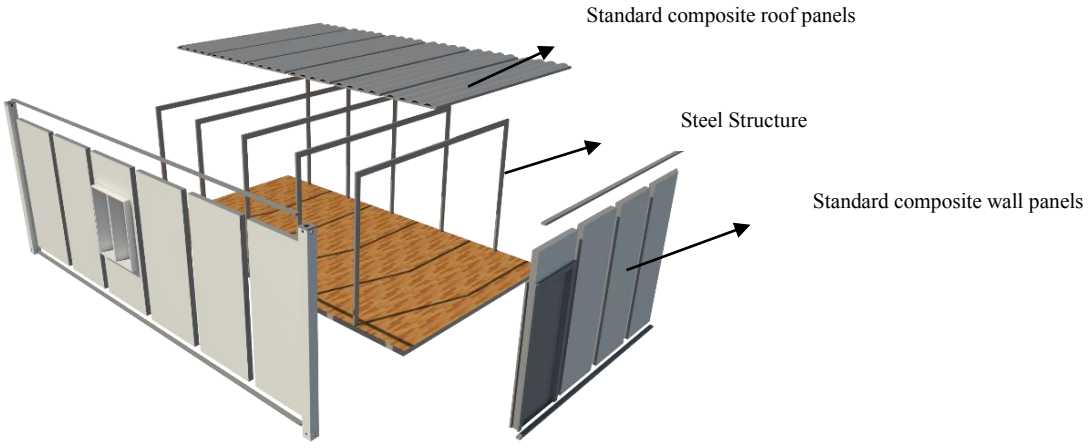


Figure 4.1: The typical structural system for Flexible shelter units

In this proposal solar panels for electric energy is also recommended; so that heavy investment for infrastructure is prevented see Figure 4.2.

Figure 4.2: Solar panels

Panel standard dimensions:

In order to make the system economic, panels' sizes (both for wall and roof panels) must be standard and as big as possible. They must be easy to carry and fix on site. In this study two standard panel sizes are preferred. These sizes are 90 cm and 120 cm which are at the same time multiples of 30 cm. The combinations of these panels are expressed in see Figure 4.3.

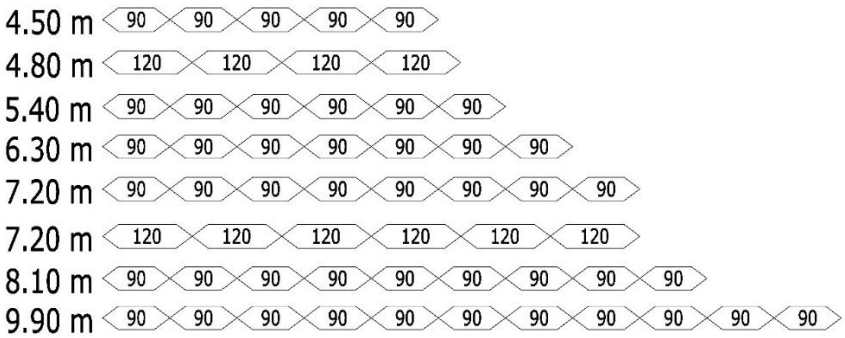


Figure 4.3: Combinations of two panels' sizes (90cm, 120cm) for planning of flexible shelter units

4.3 Flexible Design of Shelter Units

In this thesis according to family sizes and different needs developing flexible shelter units are aimed. On this basis, three types' single shelter units see Figure 4.4, three types two bedrooms units see Figure 4.5, three types three bedrooms units see Figure 4.6 with their three alternative arrangements are studied.

Alternative arrangement for single unit shelters			
Type	Number of user	Area	Details
A	1-2	19 m^2	Its contain (one bed, table, two chair, two arm chair, oven, sink, refrigerator and WC)
B	2-4	25 m^2	Its contain (two bed, table, four chair, one arm chair, couch, oven, sink, refrigerator and WC)
C	3-6	35 m^2	Its contain (three bed, table, four chair, couch, long couch, oven, sink, refrigerator and WC)

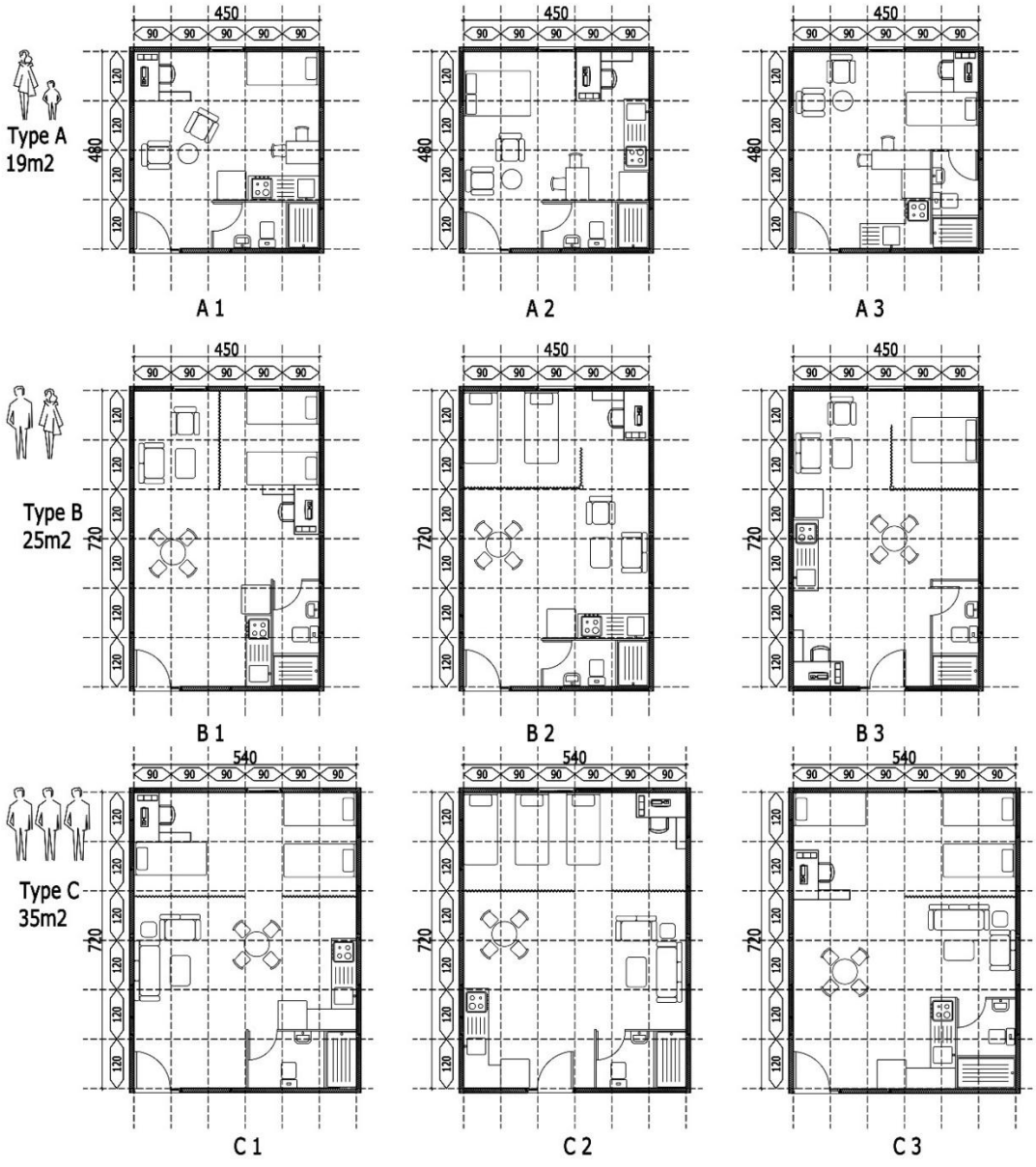


Figure 4.4: Alternative arrangement for single unit shelters

Alternative arrangement for two bedroom unit shelters			
Type	Number of user	Area	Details
A	3-4	35 m^2	Its contain (one double bed, one single bed, table, four chair, one arm chair, two couch, oven, sink, refrigerator and WC)
B	4-6	45 m^2	Its contain (one double bed, two single bed, table, four chair, long couch , couch, oven, sink, refrigerator and WC)
C	5-8	50 m^2	Its contain (one double bed, three single bed, table, six chair, long couch , couch, one arm chair, oven, sink, refrigerator and WC)

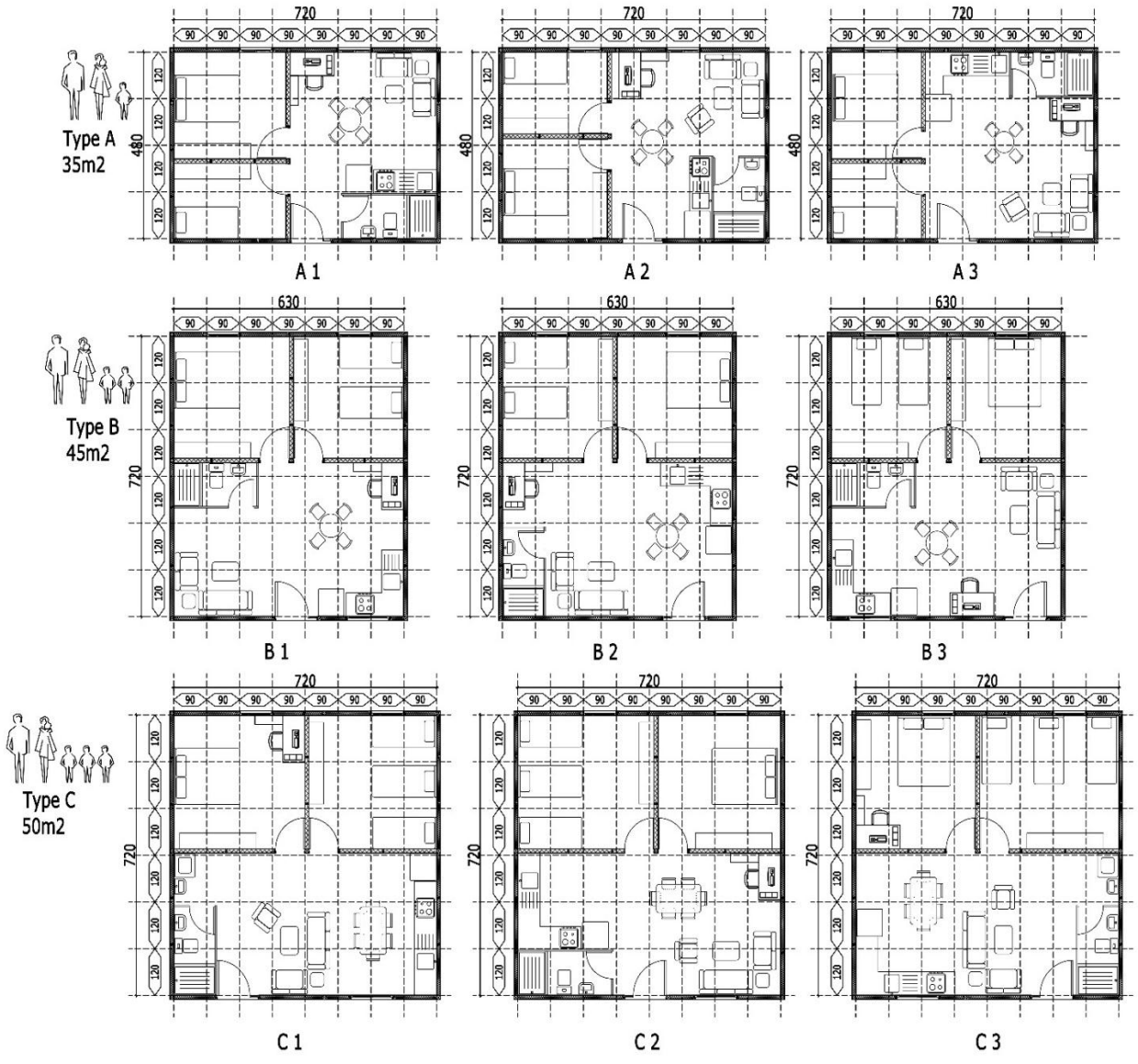


Figure 4.5: Alternative arrangement for two bedrooms unit shelters

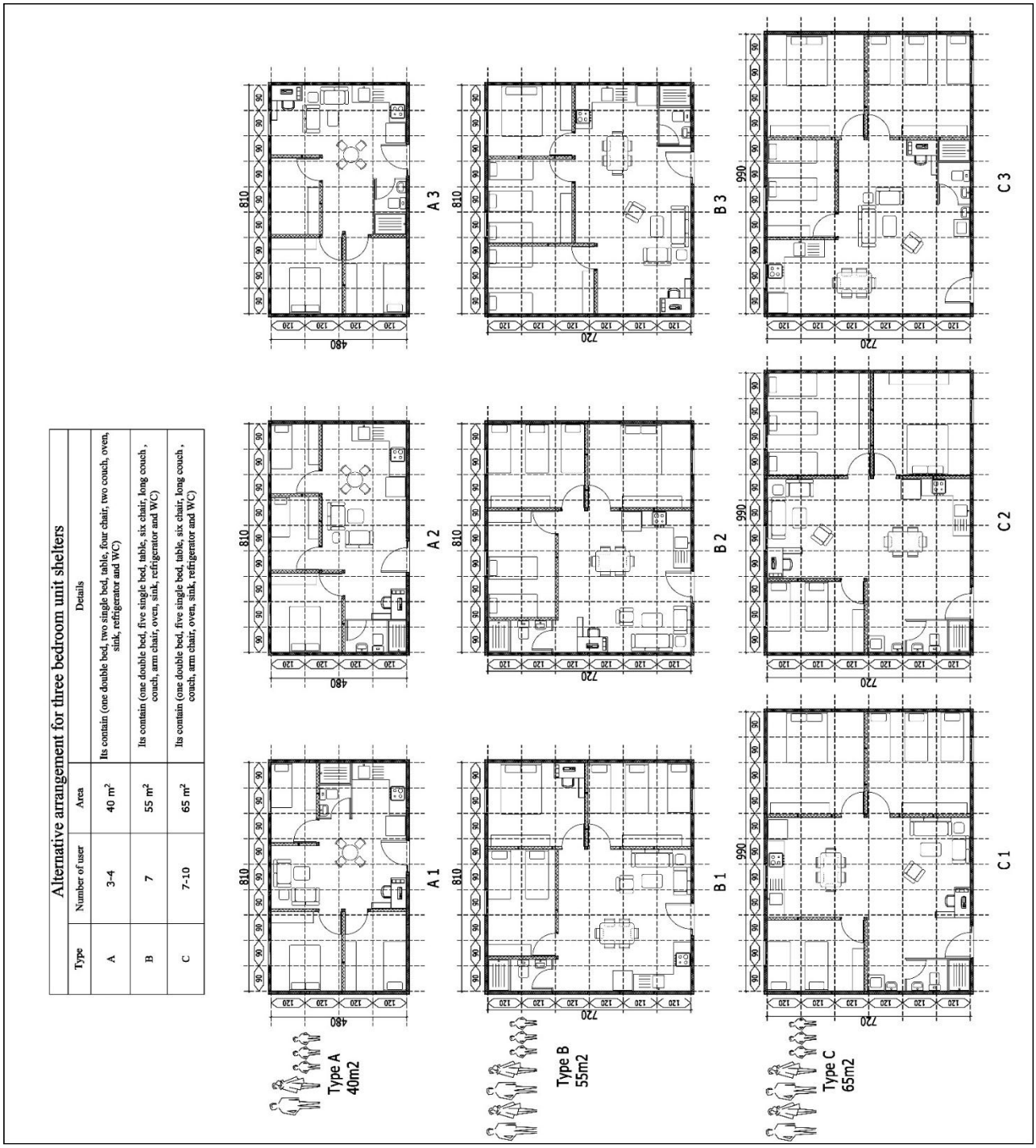
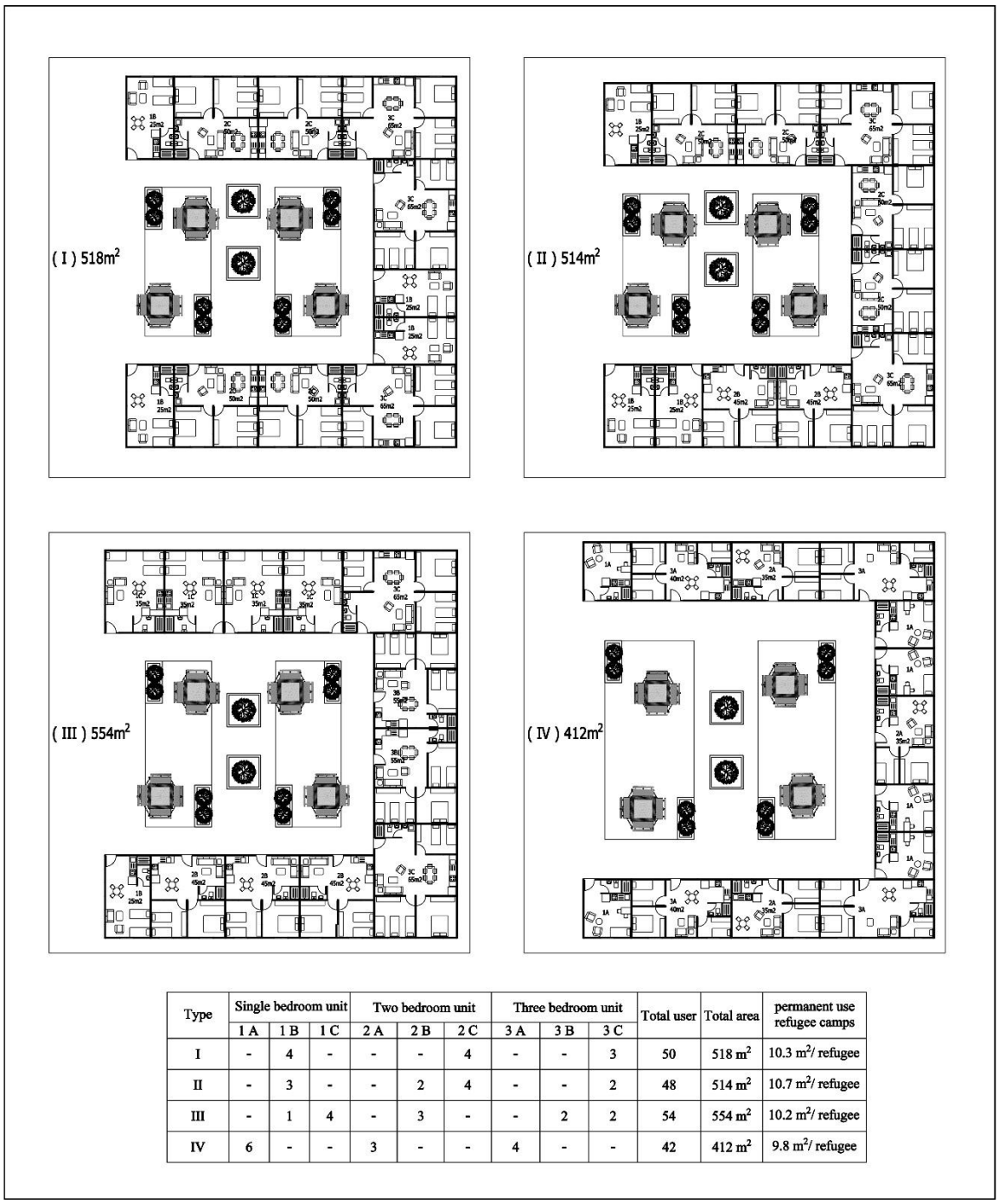


Figure 4.6: Alternative arrangement for three bedrooms unit shelters

4.4 Flexible Formation of Cluster Units

Different shelter units can be combined in various ways to form courtyard clusters. Courtyards enables refugees to socialize. They can meet, communicate and help each other easily see Figure 4.7and 4.8.



Type	Single bedroom unit			Two bedroom unit			Three bedroom unit			Total user	Total area	permanent use refugee camps
	1 A	1 B	1 C	2 A	2 B	2 C	3 A	3 B	3 C			
I	-	4	-	-	-	4	-	-	3	50	518 m^2	10.3 m^2/ refugee
II	-	3	-	-	2	4	-	-	2	48	514 m^2	10.7 m^2/ refugee
III	-	1	4	-	3	-	-	2	2	54	554 m^2	10.2 m^2/ refugee
IV	6	-	-	3	-	-	4	-	-	42	412 m^2	9.8 m^2/ refugee

Figure 4.7: Flexible formation of cluster units

Figure 4.8: 3D of cluster units

4.5 Flexible Development of Cluster Units in Urban Scale

As Rapoport (1982) says refugee's camps can well be developed such that qualified public, semipublic spaces together with semi private and private spaces can be harmonized. He says that particularly public and semipublic spaces are neglected in refugee's camps (Farivarsadri and Dehghany, 2017).

In this thesis modular flexible arrangement of cluster units enables planners to create qualified public and semipublic see Figure 4.9.

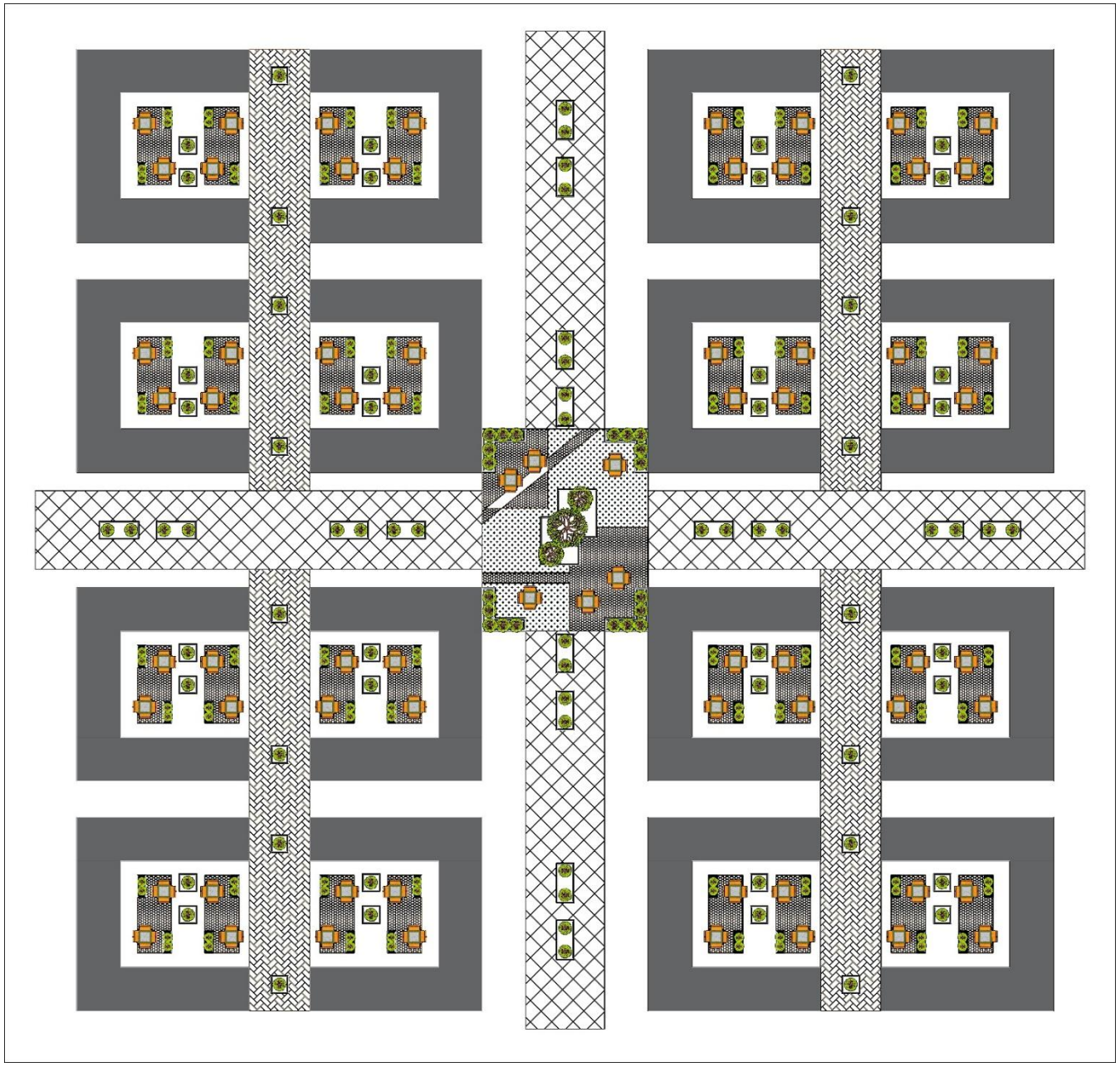


Figure 4.9: Development of cluster units in urban scale

4.6 Practice on the Selected Site

Although it's not within the main aim of the thesis, a practice will be done on urban scale to observe the advantages and disadvantages of the proposed flexible cluster units. In this case study, the area chosen for green refugees' camp will be inside of the country Azaz Syria and is accepted as safe see Figure 4.10.

Azaz can be officially protected by the Turkish army, that's very good for the civilians or even for the displaced people who run to Azaz from all over the North of Syria. That was one of the main reasons to choose Azaz as an ideal inner place to establish the camp on it.

Azaz is considered to be a northwestern city in Syria, located nearly 40 km northwest of Aleppo. According to the Syria Central Bureau of Statistics (CBS), in 2004 census reports Azaz city have had a population of 31,623 citizens.

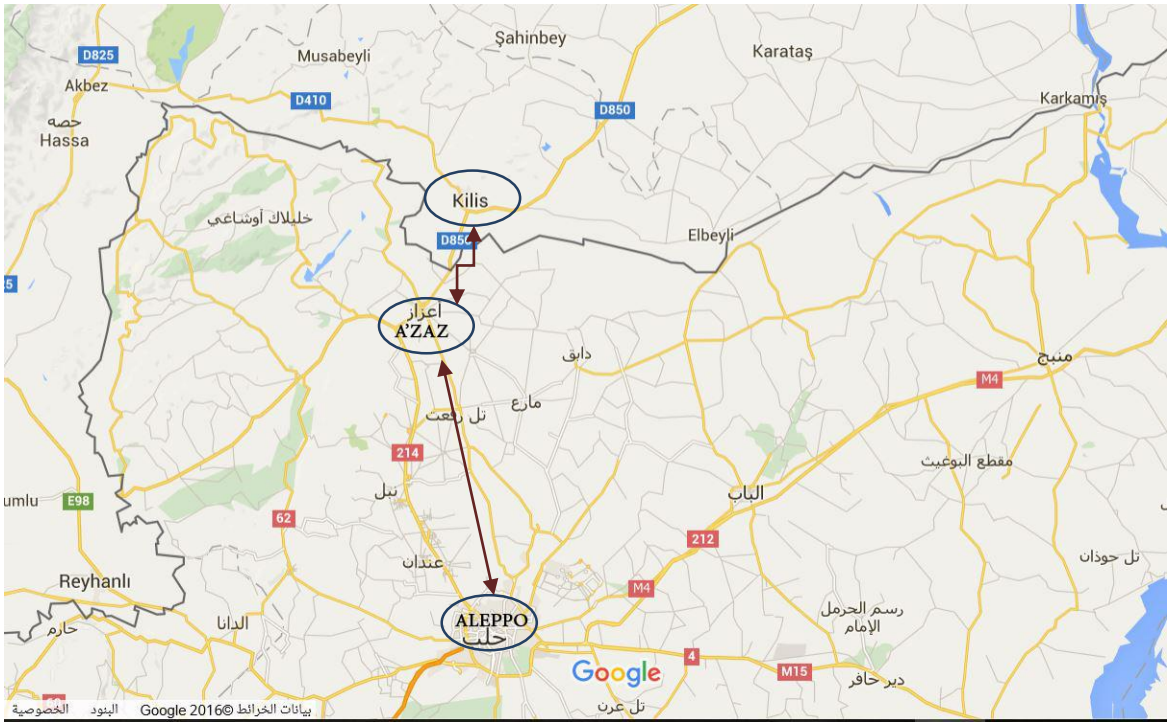


Figure 4.10: Syria, Azaz map
(https://www.google.com/maps/@36.6016749,37.0476287,12.75z)

The reason of choosing Azaz to establish the sustainable refugee camps inside it, first because of the advantages that Azaz takes in its position close to Turkey (only 15km distance from Kilis).

Secondly it has border gate with turkey called "Bab Alsalama" which plays a very big role in the Syrian conflict. According to the UN NEWS CENTRE "a huge number of displaced people that can be counted in thousands have re-grouped in Azaz area in order to search for a refuge close to Bab Al Salam border crossing point, however there are thousands more of displaced refugees are expected to come over with a condition of continuous fighting occurred. Specifics and numbers tell that more than 30 thousand people are reported to be displaced too; divided into groups fleeing through the Turkish border and to the towns of Afrin and Azaz." (UN NEWS, 2016).The transportation of food on cross-border caravan from Turkey into Azaz and all of the north cities; which helped increasing the percentages of making inner camps in Azaz. Especially, after the allegations that the Turkish government has recently made, that it will make safe area on its border with Syria included Azaz see Figure 4.11.

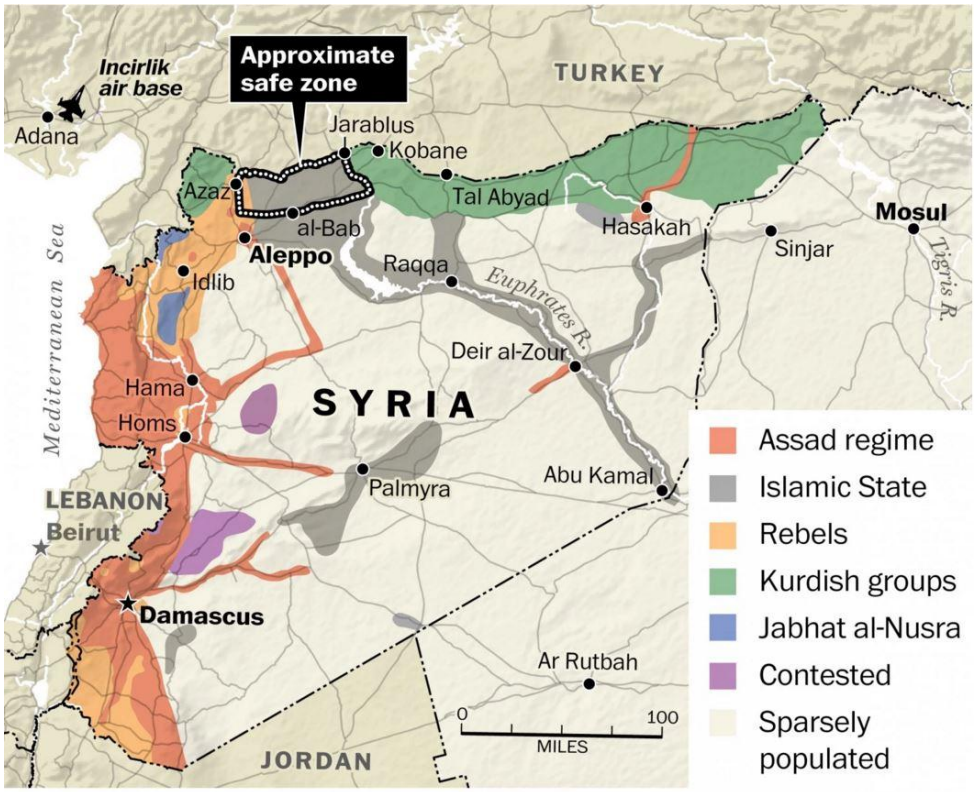


Figure 4.11: Syrian map, study of war (https://www.washingtonpost.com/world/new-us-turkey-plan-amounts-to-a-safe-zone-in-northwest-syria/2015/07/26/0a533345-ff2e-4b40-858a-c1b36541e156_story.html)

Establishing an inner camp in Syria for the inner displaced, will give a solution inside and outside Syria for the refugee's crisis.

Turkey according to UNHCR "With the beginning of Syria crisis in 2011, Turkey - is said to be hosting over one million Syrian refugees - has preserved an emergency response action of a consistently above the average standard and announced a temporary protection system, ensuring non-refoulement and support in nearly 22 camps, with a quantity of 217,000 individuals are staying.

Nowadays, Turkey is said to be constructing two more camps that can embrace more refugees."(UNHCR, 2015). That shows the huge amount of the refugees in Turkey see Figure 4.12.

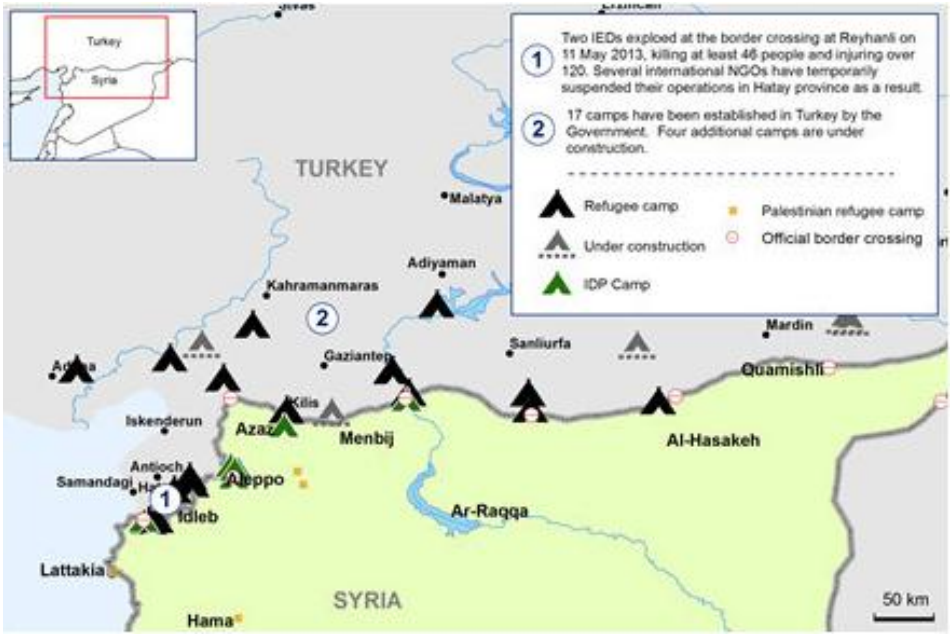


Figure 4.12: Refugee camps inside and outside Syria(http://geo.acaps.org/docs/483)

Making a safe area in North Syria will make a huge different in the refugees crisis, because most of the refugees are from North Syria whom running from the war to Turkey. Establishing extendable green camps in North Syria in safe area provided by Turkish army, with initial

capacity of 240.000 refugees can stop those people from running to Turkey, or even to Europe. Also establishing camps in border area with Turkey will provide easy transportation for the essential goods and materials for the refugees and also for building camps.

Figure 4.13: Selecting the refugee camp, and zoning
(https://www.google.com/maps/@36.6016749,37.0476287,12.75z)

The site is available to make the camp Green camp, because it has got a very good soil for various plants and trees; however, it is very famous with Olive trees. Its soil is very rich with water and nearby few water sources see Figure 4.13.

Site Organization:

Now after the site has been selected the next step is to arrange the facilities and choose the position for each. The arrangement of spaces during the site planning process must be done in a very logical and comprehensive way, to create green refugees camp and also to fulfill the refugees needs, and also to achieve the best facilities needed for having a long stay camps. Site planning of a green camp needs to have specialists from all departments for example, geology, sanitation, architecture, construction, etc. Unfortunately, this coordination between all of these sectors is very hard in case of emergency sudden exodus. It's very important to form a confirmed standard flexible design for those kinds of sustainable or green camps planning. This type of approach may become a reference for any other expected exodus in any place in the world.

This type of solution can be applicable and constructed extremely quickly in case of emergencies. And only left low amount of changeable factors to be determined according to geographical and cultural variation. This modular practice in the thesis tries to analyze sustainable refugee's camps that can be established both inside and outside of the place of conflict.

As a first step in order to break down the process of site organization drawing an abstract zone for the main major basic functions (Main axes, Shelters places, Services, and Green areas), is recommended as shown in the Figure 4.14.

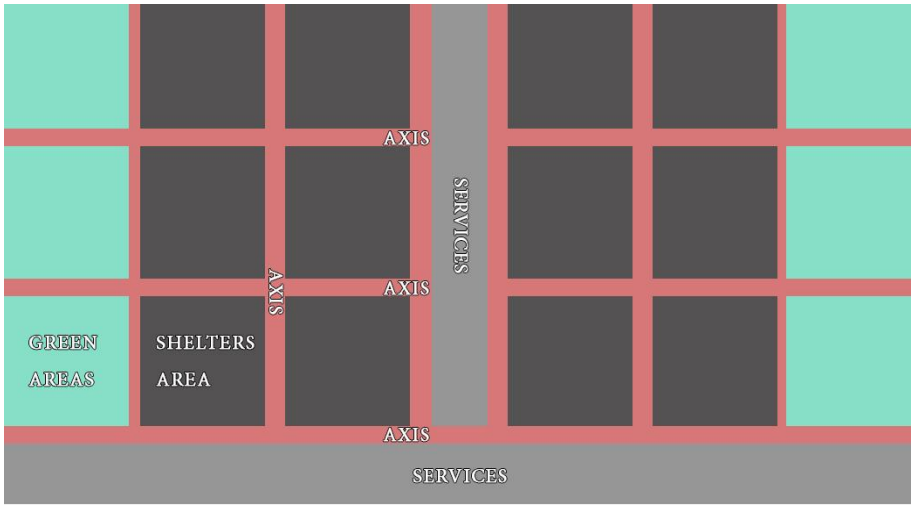


Figure 4.14: Abstract Camp zoning

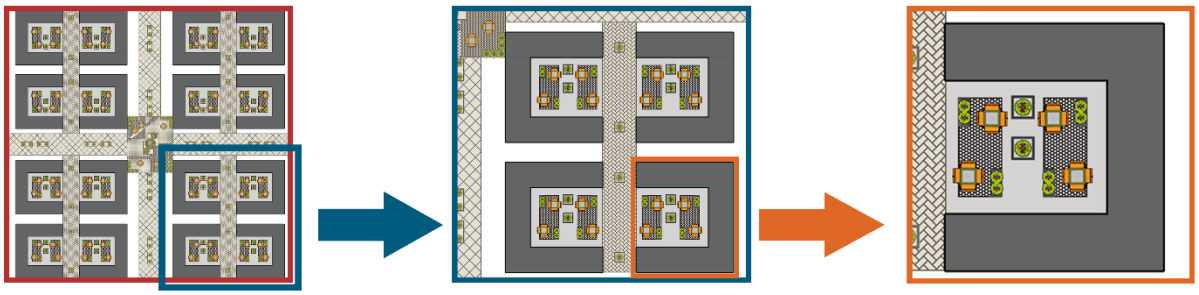
After the first step has been made and accepted and a clear vision for the site has been shown, now it's much easier to put more details and make more divisions according to the site needs.

This step will convert the colored undetailed zoning into functional detailed spaces and outline of buildings and shelters as will be described in the next paragraph "Site Planning".

Site Planning

The next step after choosing Azaz as a location to build the sustainable refugees camp, and made an abstract vision on how the main functions will be distributed, now it's the time to go deeper plan and design the camp in a way to ensure that all the facilities are set highly efficient.

Everything must be studied and planned in such a way as, to achieve the goal of obtaining sustainable green refugees camp (GRC). This step will show how all the facilities are arranged within the zoning into appropriate places to suit the function for each one of them, and also to take the most advantages of these facilities in order to help the refugees with all their needs. Some common spaces like courtyards can be created in order to let the refugees meet each other.



A part taken from camp zoningPLOT UNIT

Figure 4.15: Zone analysis of one unit

Each part mentioned above can be named as unit Figure 4.15. Also every four units create a plot. And each eight plot in row with single refugees planting area on the side of the blocks called block shown in the Figure 4.16 and 4.17.When two sections gathered together, we call them as region see Figure 4.18.

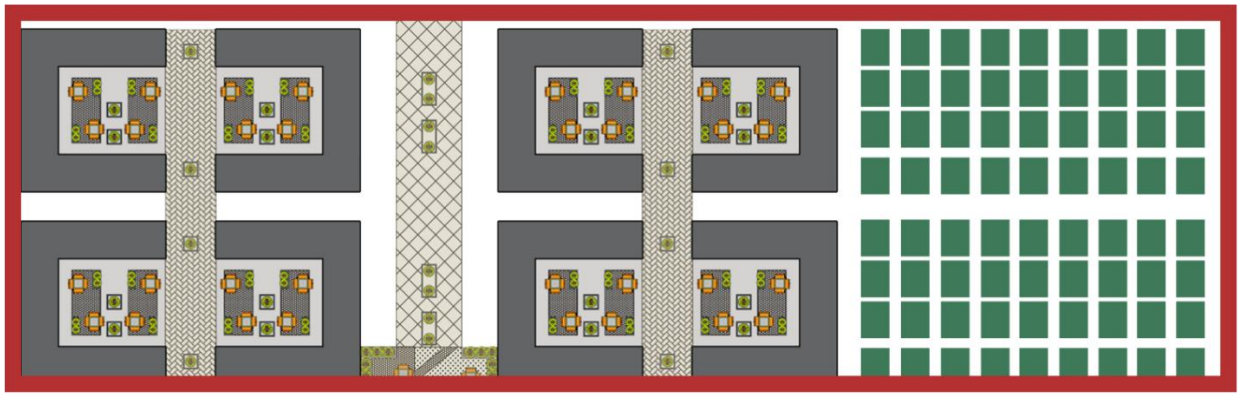


Figure 4.16: Zone analysis of blocks

Figure 4.17: Details of zoning analysis for section

Figure 4.18: Region

The one region estimating capacity is between (2550, 2640), this system of division gives the unlimited flexibility of extension. By repeating the region to fulfill any expected area and the capacity we have already chosen. In this thesis the expected amount of the inner refugees to come is 100,000 displaced people from all over Syria to Azaz, in this case the repeated number of region must be around 40 Region placed in Azaz. Exactly on the road which connects Azaz with the Turkish Gate border "Bab Alsalama".

This study gives opportunity to analyze and figure out the spaces needed by the persons living in camps. Hospital, mosques, schools, markets, parks, community spaces, and also security rooms should be considered in the urban design level to improve the sense of community. Creating open spaces and meeting points are essential considerations in order to have high level of interaction between the refugees which is very important to keep them to feel that they are normal people, and to let them communicate with each other, in a good friendly environment around them. Hospital can also be designed in an expandable way such that can be reached from inside and outside of the camp.

The major health facility should be positioned in a secure and easily reached place. It is recommended on the periphery of the site in order not to have overcrowding and also to allow the expansion in the future. The required area can be determined by the capacity of the medical service to be provided. It is also very important to design space for sanitation and water facilities, as well as room for eventual expansion.

The secondary health facilities should be located centrally in order to be reached easily in the areas they are served. The quantities usually determined by the size of population, according to the standards by UN (1 health post per 3000, 5000 refugees is required).Also, the schools located centrally in order to be approached by the teenagers easily. The green yards near the shelters let the kids to play under the supervision of their parents. The orientation of the whole camp has been established in a way that all the regions face the East, South, and West in order to take the maximum advantages of the Sun light, for producing the solar energy Figure 4.19.

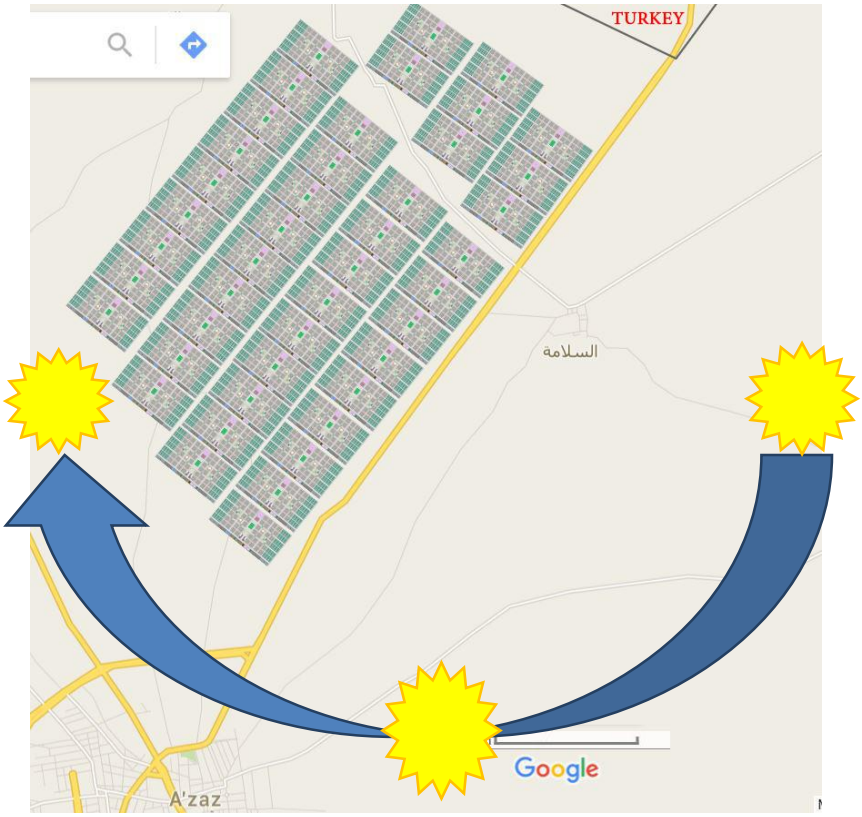


Figure 4.19: Planning all regions together

Camp can also be designed in such a way that, each shelter may own a small planting area. In order to encourage the refugees to plant their own vegetables and let them to be productive people see Figure 4.20. They may also socialize by making exchanges with each other.

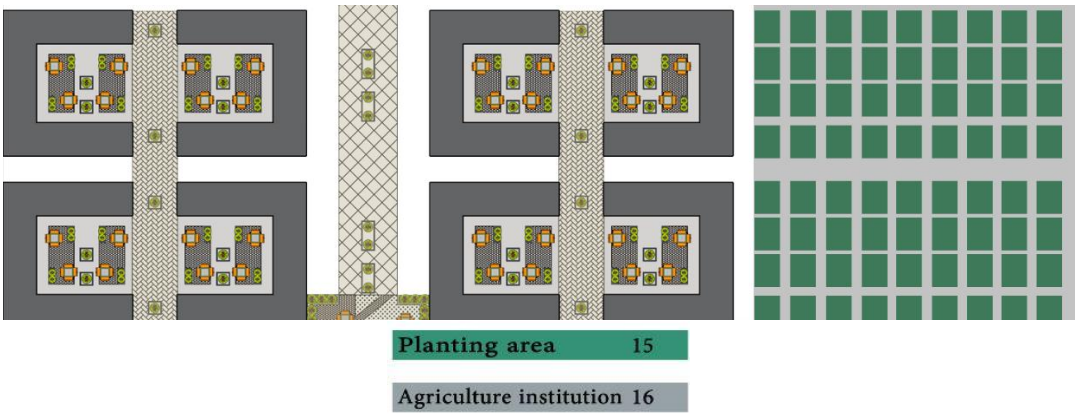


Figure 4.20: Planting areas

This social action is very important as it gives equipment (axes, seeds, handbook, special gloves, etc.) and forces refugees to produce and take responsibility. The agriculture institution should guide the refugees by giving them all the information they need. It should also help them by giving the manure and seeds needed. It is institution responsibility to analyze and balance the variation of the fruit and vegetable, planted by the refugees, in order to fulfill the needs of camp.

Green water network system which will collect all the clean wasted water can also be establish. Waste water coming from shelters or public spaces can be used for irrigation of plants. This easy and inexpensive method will save for the GRC tons and tons of wasted unused water, to be used on other purposes without exhausting the drinking water sources.

Also, the wasted food, vegetable, and fruit, must be taking advantages of them in a way to convert them to be as a good and efficient manure to the plant, and it is also will done by collecting them all in one place then with special techniques the manure will be produced.

Another great approach which converts the urine of 100.000 people into energy (40 – 47% of the GRC energy) is worth to examine.

24-hour urine has a normal volume range of about 800 to 2000 milliliters in a day (including a fluid intake capability of nearly 2 liters within a day). (Poudel and Kafle, 2015).

An average of 1.5 LT/person, which means (1.5*100,000) =150,000 LT can be collected and converted into energy by special technique.

Lastly solar panels being part of physical green method is recommended. They can be located on each shelter's roof and it's estimated to produce the enough energy to cover the gap needed to let the GRC totally green with almost zero wasting and zero outsource.

Water availability

Choosing a place for GRC is very difficult, because in a country like Syria with so many cities are damaged and the other still considered as conflict cities, there are not so many choices to be taken. In this case study, the first priority was to find safe and border city, because in any country having a war, the priority is to save lives more than anything else. But on the other hand the water situation in Azaz is better than so many sub-districts in Aleppo Governorate.

According to local citizens, lack of electricity and fitful have affected the water pumping stations which made them unable to work fully powered within most of the time. Because as known on western Aleppo that the water and electricity are not coming on the same time. This problem demonstrated lack of water supplies as an accumulated result was already most known in eastern Aleppo just before the total shutdowns. Water availability was rare in the two assessed territories of eastern Aleppo back in April 2014; within every 48 hours water was only available for 12 hours through the network (continuous).

Similarly in 2013's observations showed nearly the same cases of 2014's lack of water situations in eastern areas of Aleppo, whereas the water was only supplied for 4 hours within a day (Reliefweb, 2015). In multiple sub-districts of Jebel Saman district, the water heights had severely dropped including Zarbah, Tall Ed-daman, Haritan, and Hadher, in addition to in the sub-districts of Mare' in Azaz district, Khanaser in As Safira district, and Soran in Al Bab district. In conjunction with Jebel Saman district being likely affected by water shortages in April and May 2014 (Reach, 2014), nine other sub-districts located across Al Bab (2 sub-districts), As Safira, Azaz, and Jebel Saman (including Eastern Aleppo City), recorded severity water heights, also classified within the life-threatening category (Reliefweb, 2015).See Figure 4.21 for safe water needs severity per assessed sub-district in Aleppo Governorate on, November 2013 and on May 2014.

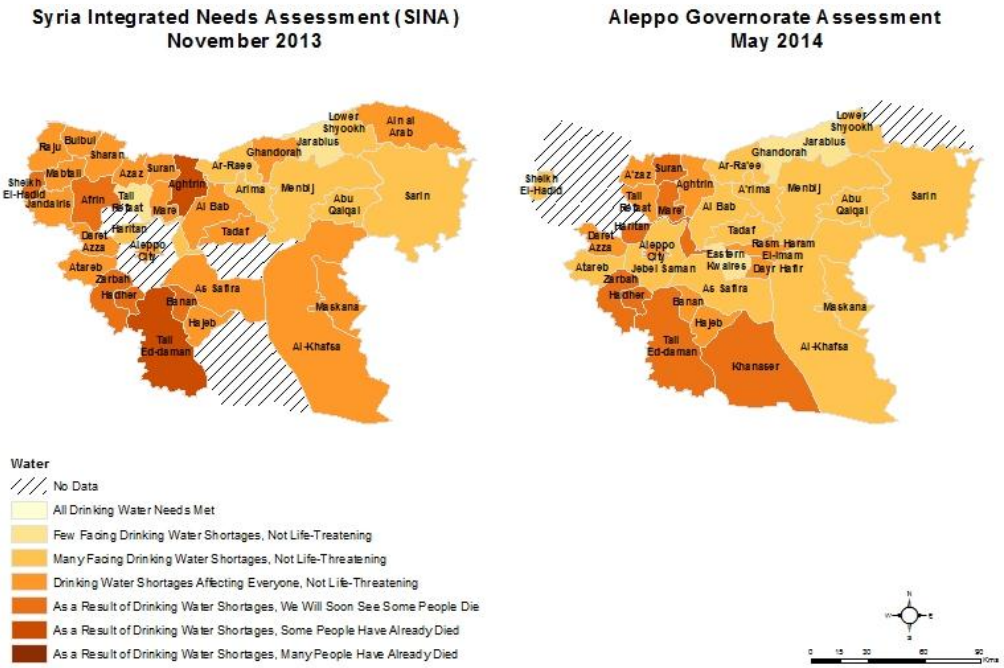


Figure 4.21: Water needs in North Syria (Reliefweb, 2015).

Problems related to drinking water provision across assessed sub-districts of Aleppo Governorate are affected by various factors, the intensity of conflict alters both electricity supply to pumping stations which subsequently affects the functioning of the whole water networks (Reliefweb, 2015).

Also, the three following issues: access to water, availability of water, and quality of water were ranked by a survey made by the Reliefweb in each sub-district, this questioned people inside each sub-district Figure 4.22.

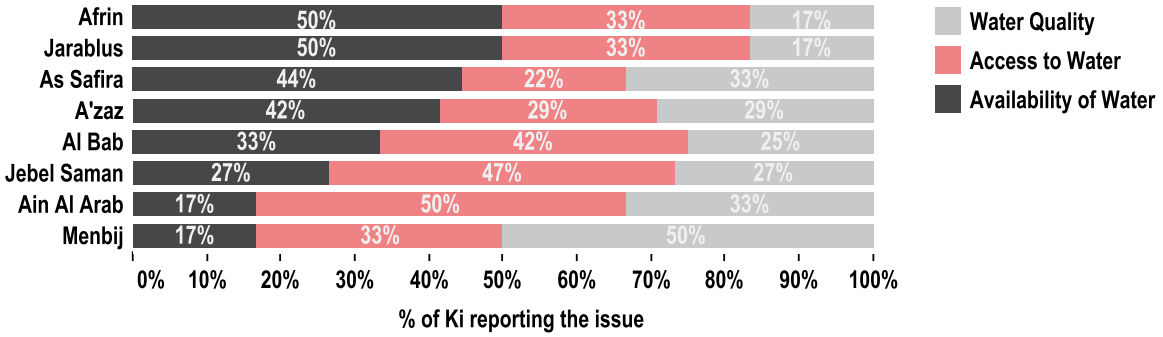


Figure 4.22: Major Water issues in assessed districts of Aleppo Governorate (Reliefweb, 2015).

The local citizen's answers vary across assessed sub-districts, this relied considerably on such factors as the local security situation, population density, proximity to a water source, level of access for humanitarian actors.In Afrin, Jarablus, As Safira and Azaz, the availability of water were the main issue mentioned. In Al Bab, Jebel Saman (excluding Aleppo City), and Ain Al Arab districts, said that the access to water is the main issue, the residents in Menbij were the only ones to rank water quality as their most relevant issue, followed respectively by access to water and availability of water.

Generally speaking, the information taken by local citizens conclude that the main water problems are a result of the local operations of the water systems which are the main sources of safe drinkable water. The water network system is in turn widely influenced by shortage of power, electricity or fuel. As a result of deficiency of different diverse drinkable water sources, a sequence of problems accompanies then arises for these main issues, consisting of; shortage of water storage containers and the inflation influencing drinking bottled water. For instance, it is possible to sentence the fact that such struggles are influencing first and major the needy population groups that neither own personal power generators to be able to pump water nor resources to be able to afford drinkable water.

"A major common drinking water origin chivied within the former month was reported to be water delivery by trucks in nearly 40% of villages estimated, the water lattice in 23% of villages and open or closed wells in 29%. More than 70% of the villages have predicted a loss in the volume of drinkable water sources within the former month across the country, most likely due to a shortage of electricity, damaged public water network system and lack of fuel for generators at water pumping buildings."(Reach, 2015).

As a result of this statistic, action becomes a necessity, this is possible by letting the number of the trucks carrying water, enter from Kilis Turkey to the Azaz and the GRC, by taking advantages of the geographic features of Azaz. And then the water could be distributed by local trucks to the surrounding villages. This must be under control by the Turkish army which will provide secure conditions to let the water reach to the maximum amount of water needed people.

And also repair the old wells and digging new ones in the villages with damaged water networks, because fixing the damaged water network is inefficient and also all the water sources are under the Syrian regime army.

Food availability

100% estimated subareas in Aleppo Governorate are currently facing extreme food shortages. Highest food hazardous degrees were noticed for Rasm Haram El-Imam and DayrHafir subareas in Al Bab district, Hadher sub-district in Jebel Saman district and Khanaser sub-district in As Safira district.

Besides the contention tormented eastern Aleppo City territory for which the severity rate is provided only demonstratively, these four sub-locales were the only ones to record a high hazard level ("regarding upon lack of food resources, some people already suffer from hazardous malnutrition") in Aleppo Governorate. Additionally, 13 other sub-locales located across Al Bab, Menbij, As Safira and Ain Al Arab districts recorded expansion of higher levels than the past months ("as a result of the lack of food, we will soon notice a hazard malnutrition"), also arranged within the life threatening category.However, lowest food severity levels were noticed within 5 sub-locales, located across Azaz ,Jebel Saman, and As Safira districts, where local people reported that "many people are facing the lack of goods, but it's not life-threatening" (Reliefweb,2015).

As a matter of fact, food security situation nowadays has been vastly affected across assessed sub-districts of Aleppo Governorate by various factors: the high level of conflict, difficulty to obtain access, the distance from the Turkish gate border, the population density and the number of inner displaced people. These factors are affecting on the value of food products and may raise food insecurity in areas where the population heavily relies on markets for food (Reliefweb, 2015)

Azaz district has recorded the lowest three levels of food security; while all of Jarablus district (lack of food is affecting everyone, but it's still not considered as life-threatening) according to local residents. These zones are the ones were the only two inward displaced individuals camps bunches in Aleppo Governorate are located while informal agreements are dominating in other districts. Azaz and Jarablus which are in proximity to the Turkish border, receive significant

humanitarian aid and are not high conflict areas (Reliefweb, 2015).See Figure 4.23 for food needs severity per assessed sub-district in Aleppo Governorate on November 2013 and on May 2014.

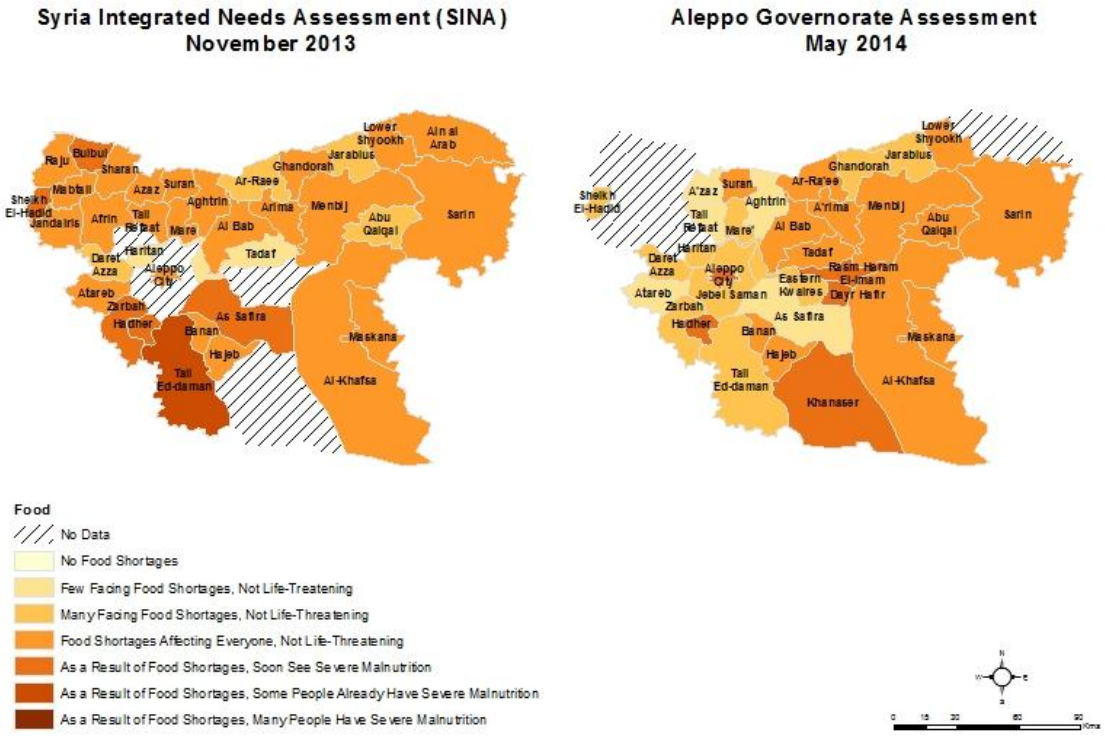


Figure 4.23: Food needs in Northern Syria (Reliefweb, 2015).

Fortunately, during the previous months according to the local residents in Azaz, their was a food increase across the border areas and the other areas close to them which may be discussed by the supplying of humanitarian aid. This is the power point in our case that our GRC should depend on at first, in order to feed the displaced people by humanitarian aid provided and delivered through the Turkish border. Then the next step will come to achieve the purposes of the GRC, which includes reducing the income of aids and depends on what the GRC's people will plan, relaying on specific plans putted by the agriculture institution, in order to cover the GRC needs of food and vegetables.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

It should not be forgotten that living in the camps is not the choice of the refugees. These people were forced to live in these camps with limited freedom of movement, inadequate living, health and education conditions. It is the duty of all humanitarian organizations and authorities to improve these conditions and provide them with better living conditions. Refugee spaces should be designed as more humanistic spaces. Naturally, economic, technical, and functional matters are the main issues that need to be considered first in the organization and placement of camps. On the other hand, it is very important to improve the sense of belonging and community in terms of their psychological and social status. Architects also have duties to design more livable environments. International and national organizations working in this field must also understand the importance of this issue and go for a closer cooperation with the designers. Camp areas, should not be the places where only the functional aspects of temporary shelters are considered and where solid military ordnance of shelters are located. Camp areas must have public spaces where people can define and socialize.

In addition, creating social spaces, parks and gardens, and open public spaces can provide medium or environment for building healthier social relationships. At the same time, well-thought-out squares, streets, urban elements can help in creating commitment to a place and being part of a community. Such measures may transform a temporary settlement into a permanent solution.

Refugees, like all other people, have the right to live freely and honorably. Designers and architects can contribute to improving the quality of life of refugees by designing better housing and camp sites. Since it is a much more difficult process to improve the conditions of a camp after the settlement, the institutions responsible for this issue should actively involve the designers together with the users (refugees) in the decision-making stages in this process. In addition, architects need to use their knowledge and skills to design more humanistic camps.

As mentioned before, normally in case of war or environment disasters, the displaced people are provided with temporary shelters and basic infrastructures, that’s way the results are always

disappointing at all levels. In this thesis, a study had been made on refugee camp clusters which can be organized in a flexible way. Prefabricated wall and roof panels with dimensions of 90cm and 120cm are preferred and multiples of combinations are produced for alternative plans. Each alternative can satisfy the needs of refugee household according to their household (family) sizes.

Within this flexible design, solutions are tried to produce answers for physical and psycho - social needs of refugees. Modular development of courtyard based clusters also enables various organizations at urban level design. The thesis proposal focused on long term stay camps and recommends to use concepts of green design in the construction of refugees camps. By this approach, it can be recommended that refugee's camps can change of being heavy load and burden for the hosting country to a very productive and more sustainable settlement.

Although, the aim of this study was to develop modular flexible shelter clusters for refugees such that they will satisfy both physical and psycho-social needs of their users, the green method approaches are also deeply studied and the psychological and the physical methods in urban level are encouraged to make the refugees camp green and more efficient. Organization of efficient physical environments or spaces can be meaningful if people are socially organized.

Establishment of psychological health center to heal the refugees and qualifying the refugees to be able to work and becoming productive people must be one of the main targets in these camps. Enhancement of the common areas may reconnect people with each other and improve friendship feelings inside them. It should be noted that in most of the camps refugees feels themselves as prisoners.

In this thesis, various physical methods and techniques are considered to improve the sustainability of the refugees camps, including green shelter materials. Energy demand of the camps can be solved by renewable resources. Reuse of water and reuse of waste food solutions may bring many advantages from economic point of view for a long term stay camps. Planting of fruit and vegetables by the refugees themselves, can create small trades among them and give opportunity for getting extra income. Finding job is an important issue for refugees. They can work in the camp institutions and in other offices of the camp. The case study focused on Azaz Syria as inner refugee's camp where the green refugees camp could handle more than 100,000

displaced people running from north Aleppo toward Turkey. It can be said that, by the green refugee camp made in Azaz, the displaced people crisis can be decreased significantly. It will also decrease the amount of the illegal emigrations to Europe.

In this thesis study, it is believed that modular flexible shelter clusters can satisfy refugee's physical and psycho – social needs. It is also believed that flexible modular approach and standardization being tools of green design provides economy. Nevertheless, green camp considerations together with humanitarian actions can create loyalty and finally these camps can be used as permanent settlements.

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APPENDICES

Sustainable Materials

There are several factors that determine sustainable or green construction and these factors, are also important in determining the selection of the green materials for the construction of sustainable buildings. Generally, green construction involves the process of constructing structures that promote the recycling of waste material, low energy consumption during construction and during the structure occupancy, preservation of the natural biodiversity, provision of aesthetic appeal with minimal destruction of the natural ecosystem, reducing carbon dioxide emissions, filtering and prevention of toxins from the air and water, and prevention of physical and chemical land degradation. Therefore, selection or design of the construction material must put into consideration the standards that are necessary when designing green buildings. Green or sustainable shelters therefore focuses on the selection, design, and use of wall material and the roof material that meet the standards of sustainable construction. The green material must either be recyclable or must have come from procedures that promote low-carbon combustion (Mills et al., 2012).

Green Walls

Green engineers have discovered that sustainable construction needs to take into consideration the nature and type of walls. The material and wall type must promote the preservation of natural bio-diversity and promote the preservation of safe ecosystem. Walls are important in the provision of human shelter as they determine the indoor air quality, home energy consumption, levels of sound pollution, and indoor temperatures. Green construction material used for designing sustainable building must always have the aesthetic value, high durability, and low ecological impact, efficient in embodied energy, high-performance capabilities, valuable social and cultural impact as well as being cost-effective.

Since the discovery of various innovations that promote low emission of greenhouse gasses, engineers have increasingly wanted to understand some of the wall construction material that offer sustainable living solutions. Cross-laminated Timber (CLT), Clay Bricks, soil interlocking

bricks, natural wood, and recyclable wall construction material are important in green construction (Mills et al., 2012).

Precast Copper Slug & Precast Concrete

It is nowadays common that engineers are fond of misusing concrete during their construction practices. According to build engineer well-familiarized with the green construction procedures, recycling of waste material in the construction industry can be an important step in enhancing the use of green construction techniques. Nonetheless, the onsite concrete waste can be very important because it can form precast concrete slabs that engineers can reuse in the indoor house partitions or other construction purposes.

When combined with copper slugs obtained from other industrial residues or home residues, the recycled onsite concrete can form various slabs that are important in the construction of sustainable buildings. Recycling onsite concrete waste or copper slug obtained from other industrial residues requires the minimal burning of coal, minimal use of combustible energy and minimal destruction of the natural ecosystem. Therefore, precast copper and precast concrete can be important green construction materials see Figure 1 (Mills et al., 2012).

Precast kerb using copper slag

Precast concrete internal partition wall using copper slag

Figure 1: Precast concrete internal partition walls using copper slag & treatment of copper slag (Huan, 2012)

Clay Bricks as Sustainable Wall Material

Although nowadays considered as conventional means of constructing contemporary high-performance buildings, natural clay bricks are important green building materials. Bricks, when well-developed can provide long-lasting walls that are cost-effective in their maintenance, with low environmental impact as the bricks do not contain chemical matter that can expose the inhabitants to health hazards whenever eroded into the water sources. Clay bricks do not also allow chemical gas emissions that can cause irritation or respiratory problems to the occupants. Even though the clay bricks may not be sufficient enough to eradicate the use of unsustainable construction material due to its nature of being highly erosive when continually exposed to water, bricks are wall materials that provide a natural ambience that promotes sufficient energy consumption, proper insulation from cold and heat, adequate protection from sound and noise pollution, and reduction of greenhouse pollutions.

Unfired Clay Masonry or the Soil Interlocking Bricks

Compared with other alternative wall construction material, unfired clay masonry is an important build technology in the green construction as it is a low-impact building material. The basic characteristics of the unfired clay masonry make it relatively robust, highly fire resistant, and with several thermal mass benefits that make the product subsist with moderate internal humidity levels. Unfired Clay Masonry is suitable for constructing both load bearing and non-load bearing walls for the residential and industrial house units. Even though clay masonry remains a conventional construction instrument, the modernization of the green usage of clay bricks has made it remain increasingly important in the construction of modern buildings (Sutton, Black &Walker, 2012). The compressive strength used in the unfired bricks is similar to the compression used in the Air-Crete block work (Sutton, Black &Walker, 2012). Unfired Clay Masonry allows low carbon form of masonry and vapor-permeable wall construction see Figure 2.

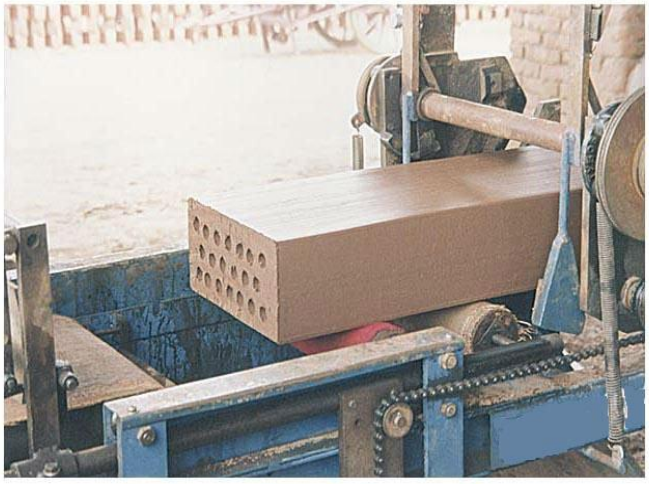

Figure 2: Clay brick making machine

(http://www.machineto.com/china-bao-shen-jky-50-50e-40-soil-brick-extruder-important-brick-making-machinery-in-the-clay-brick-plant-10076606)

Cross-laminated Timber (CLT)

One of the outstanding green technologies that have spurred a new interest in the use of sustainable wall materials is the Cross-Laminated Timber. Cross-Laminated Timber is an engineered wood product with the best structural properties necessary in meeting the environmental construction standards. The CLT has the potential to provide dry, fast onsite construction, with the most desired air tightness and a robust wood structure with appropriate internal and external finishes. The wood is manufactured aboard and with the use of environmentally friendly manufacturing procedures. In the United States, CLT engineers have managed to construct a nine-storey building (Sutton, Black &Walker, 2011).

The material stands out as an exceptional wall and floor construction element because it is a renewable raw material that keeps carbon dormant throughout its lifespan, provides a fast onsite construction and a vapor-permeable wall construction. Such features make the CLT an exceptional construction material for green construction solution see Figure 3 and 4.

Figure 3: CLT: Cross laminated timber (HYBRID Build Solution, 2013)

Figure 4: CLT – Cross laminated timber being installed (SCS, 2013)

Eco-Beams & Lattice Beams

The most devastating issue in the construction of contemporary walls for the residential and industrial structures is the continued reliance on cement that is essential in the construction of concrete walls. The process of manufacturing cement is normally environmentally unfriendly even as people continue ignoring its negative impact. Eco-beams are some of the alternative green construction materials that are important in the design and construction of high-performance buildings. When proficiently combined with other construction materials that serve the green construction standards, eco-beams have the much-needed aesthetics, can be manufactured onboard, are eco-friendly, encourage minimal building waste or onsite material waste, and have superior acoustic qualities (Getter &Rowe, 2006). Most important is that the manufacturing and onsite use of eco-beam is environmentally friendly because the carbon

footprint is much less than conventional construction materials. The eco-beams can be reused, recycled and disposed of in the most environmentally friendly manner.

Figure 5: Steel frames in Buildings (Wallace, 2016)

Steel & Other Prefabricated Parts

To reduce the number of non-biodegradable matter on earth, which glass and industrial steel comprise the majority of these pollutants, reusing steel and glass can be another significant green building mechanism (Getter &Rowe, 2006). Steel is an exceptional reusable construction material Figure 5. Independent engineers and designers around the world have conducted the Life Cycle analyses on steel and concluded that steel is an environmentally friendly construction product because its lifetime environmental impact is minimal. Hence, the results have allowed designers to have the confidence of specifying steel and glass products in their various kinds of construction purposes. Nowadays, steel and glass are working in combination to construct various forms of buildings ranging from single storey buildings, low-rise buildings to high rise buildings. Converting steel for other construction purposes requires the minimal burning of coal and energy use. Thus, steel and glass are alternative construction material for the low rise and high rise buildings that were initially constructed using concrete (Getter &Rowe, 2006).

Green roofs

Roofing is an essential element in green building. Roofs often regulate the indoor temperature as they determine the amount of heat that penetrates the inner part of the house (Getter &Rowe, 2006). Since the realization of the need to conserve the environment through embracing green construction material, engineers have sought several solutions to the green construction in which traditional roofing seems to restore to life. When it comes to green roofing technologies, the two most important terms that dominate the real of sustainable construction is the extensive or intensive roofing type depending on the type of plant material and the design implemented in the green roofing.

However, there are several other green technologies that have come to compliment the tradition plant roofing materials that people would often consider sustainable when it comes to their preservation of the natural bio-diversity and their eco-friendliness. Green roofing involves the use of materials such as those discussed below (Getter &Rowe, 2006).

Bamboo thatches can be important green construction roofs that are capable of offering sustainable construction solutions due to their ability to provide low-cost transitional shelter option to the build engineers. Dried bamboo wood and palm leaves are some of the cost-effective and sustainable roofing options that provide occupants with attractive and natural ambience that is free from pollutants.

The two roofing materials are naturally extracted from their sources without any polluting processes or procedures that affect the environment or the future sustainability of the material. Bamboo leaves and palm leaves are important for sustainable survival because they are significant in increasing home energy efficiency see Figure 6 (Ferreira &Mainier, 2015).

They ensure home energy efficiency because they enhance home cooling during summer seasons and provide wind and cold insulation during the winter seasons. They also provide occupants with filtered rainwater and air as they filter air and water toxins.

Figure 6: Material bamboo (Bamboocreasian, 2013)

Figure 7: Palm thatch used in roof (Ama Zulu, 2016)

Clay and Concrete Roofs

Green building involves the use of sustainable construction material. Sustainable construction materials are materials obtained from eco-friendly procedures that promote the use of recycled matter to avoid environmental pollution, reusable material to avoid the use destruction of the ecosystem, and sustainably manufactured material to reduce the impact of carbon and other pollutants on the earth. Clay and concrete roofs have been in use since time immemorial and

their aptness in sustainable construction has remained exceptional see Figure 8. A combination of clay and some concrete to produce concrete tiles that form perfect green roofing solutions has remain an important green engineering practice. Besides from being in abundance and easy to source locally for convenient construction, the main ingredients of sand and cement in concrete tiles are recyclable as well. These concrete roof tiles are energy efficient, are cost-effective, and insulate the structure against sound, extreme heat and noise (Ferreira &Mainier, 2015).

Figure 8: Clay and concrete roofs
(https://upload.wikimedia.org/wikipedia/commons/9/9d/Roof-Tile-3149.jpg)

CertainTeed Roofing Products

Another emergent technology in the green construction realm is the CertainTeed roofing innovation that has proven efficient in promoting green construction solution (Scott, Edge& Laing, 2006). In the United States, CertainTeed Roofing has become a significant green building solution because the CertainTeed materials are obtained from slag, stone granules obtained from soil, corrugated mixed paper and sludge or mud see Figure 9. Apart from the fact that the materials come from various recycling processes, some products contain up to 80% post-consumer and post-industrial recycled matter, and hence, proving very significant in contributing to environmental sustainability. The use of CertainTeed Vinyl siding, Restoration Millwork trim, and Cedar Impressions also provide the build engineers with opportunities to

increase the sustainability of their construction projects. The use of pre- and post-consumer and industrial recycled content is an essential element in determining the sustainability of the construction material as it also contributes to the reduction of landfill waste (Scott, Edge& Laing, 2006).

Figure 9: Certain teed roofing products (http://www.lymanlumber-wi.com/products/roofing/certainteed1.jpg) (http://www.forefrontco.com/wp-content/uploads/2016/02/Certainteed-04.jpg)

The Green Roofs

As engineer continue seeing solutions to the match anticipated sustainable constructions, people are coming up with various construction solutions to meet the standards of Leadership in Energy and Environmental Design (LEED). An important innovation in the green construction that has captured the minds of many engineers is the use of green roofs see Figure 10. Green roofs are house tops made of naturally growing green grass planted on top of the buildings with the use of a growing medium (Mills, Lawrence, Rakheja, &Darwich, 2012).

The growing medium is normally a non-perforated or a waterproofing membrane. The grass used is normally fire proof and its growth is limited to certain heights. The weight exerted by the grass vegetation and the growing medium does not cause serious pressure on the building. Unlike the galvanized iron sheets obtained through rigorous manufacturing practices, the green roofs are rooftops designed with minimal use of energy, little environmental impact and even little harm on the natural biodiversity (Ferreira &Mainier, 2015).

Figure 10: Green roof layers (http://dcgreenworks.org/wp-content/uploads/2011/12/green-roof-layers2.jpg) (Guz Architects, 2010)