Tiwari *et al. City, Territory and Architecture* (2023) 10:2
https://doi.org/10.1186/s40410-022-00184-z

City, Territory and Architecture

RESEARCH ARTICLE

Open Access

Sustainable refugee camp design in the Dalhamyie settlement (Bekaa, Lebanon) for climate change context

Pallavi Tiwari[1*], Nibal Al Azzawi[2] and Lübna Amir[3]

Abstract

Emergency shelters are often designed to be of temporary nature but end up adopting a more permanent nature in becoming informal settlements. On one hand, these settlements suffer from the conflicts and environmental pressures. On the other hand, they also bear the inadequacies of services and facilities. This adds to the vulnerability of the refugee population to climatic extremes and environmental extremes along with a low quality of life. The present study aims to identify the pressures both environmental and socio-economic on a refugee camp in the Dalhamyie settlement in Bekaa, Lebanon and design a resilient model which address both internal and external risks. We propose a master plan as a suggested guideline representing a preliminary design umbrella plan that may be updated and altered depending on the population of the community, the site's limitations, and the general availability of resources. To help the local refugees become more resilient and self-sufficient in times of crisis, recommendations are here presented are not strict structural plans but rather a strategic, data-driven collection of actions. With the increasing mental stress that refugees experience, the idea of resilience at all levels is needed to lessen and reinforce the constant environmental, physical, and economic threat that they are subjected to. Residential zoning has been detailed out with respect to the form, structure and assembling of components along with cluster planning within the settlement. Recommendations are not a rigid structural plan but a strategic, data driven set of actions that can be implemented by the local refugee community in order to achieve greater resilience and self-sustainability during crisis situations. Such model is applicable with modifications for other emergency settlements also with varying risk factors. The proposed model addresses the challenges and the multiple risks that the people are exposed to present a framework that can lead to better quality of life in temporary settlements. With more climate refugees, conflict driven refugees and internal refugees, absence of such models was a gap and the authors have tried to build the same through one case study.

Keywords Emergency shelters, Resilient design, Master planning, Informal settlements, Temporary shelters, Refugees, Strategic camp planning, Climate change, Vulnerable community

Introduction

Since 1951, people who had to leave their homeland are at the heart of concerns of the international community. A convention was ratified by state parties and then improved to define and to protect the rights of the refugees.[1] Unfortunately, conflicts and disasters force

*Correspondence:
Pallavi Tiwari
pallavitiwari1401@gmail.com
[1] Department of Physical Planning, School of Planning and Architecture, New Delhi, India
[2] Architectural engineering Department University of Sharjah, Sharjah, UAE
[3] Department of Geophysics, Faculty of Earth Sciences, USTHB Bab Ezzouar, Algiers, Algeria

[1] The Refugee Convention. https://www.unhcr.org/4ca34be29.pdf UNHCR, 1951.

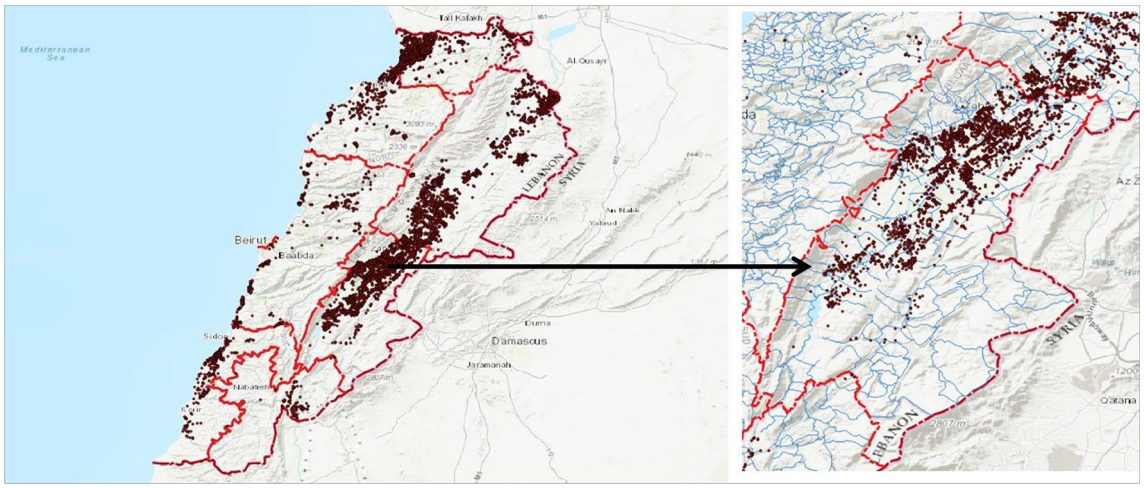

Fig.1 Informal Settlements (left) in Lebanon, (right) in the Bekaa Valley (Source: Data from UNHCR 2020, Software used: QGIS)

populations to be displaced in places that do not meet the basic standards for their family. Different types of refugees can be identified. These are (1) those coming because of political conflict (places totally devastated), (2) the internally displaced people related to climate change (drought, flash floods, lack of water and other such climatic risks) or natural disasters (earthquakes, flood, hurricanes and etc.), and (3) circulated people who just come to spend time in the camp before they come back to their country after they had to leave it. More often than not, the refugees that settle at a place, due to political or physical constraints, stay in those temporary locations for an extended period of time. Between the two ideas of a refugee camp as a "permanent" VS "temporary" solution, there are many possible intermediate situations. This calls for a flexible strategic approach because it involves the same camp passing through several socio-spatial stages and phases from a temporary arrangement to a more static informal settlement (Aburamadan et. al. 2020). The process of rebuilding the damaged areas (houses, infrastructures and facilities) can last a long time. In some cases, conflicts in places where wars totally devastate cities may last for several decades. Consequently, refugees cannot get back home and are most often left with no ID resulting with no rights and no access for education, work or health care (ILO 2019). Moreover, while they strive to survive in camps, they undergo other disasters such as hurricanes, floods, landslides or destructive earthquakes that weaken their already fragile shelters (Ezezue et al. 2019). Poor location choices for such shelters, inadequate consideration of climatic conditions, limited locally accessible resources and skills, cultural and social concerns, delays, and economic constraints have all been recognized as factors of poor performance that contribute to an undesirable standard of living (Bashawri et al. 2014). The two main objectives of contemporary emergency camps are to (1) provide fundamental human needs and (2) deal with a quantitative issue. Refugee camps should be thought of more as urban settlements than as a series of shelters. The urban design of the refugee camps brings to mind the idea of creating communities and organizing the space between structures and related social ties (Aburamadan et. al. 2020). In settlements that are a result of the political conflict, refugees require social and economic support. Shelter and settlements cannot, by nature, be completely divorced from their social, cultural, environmental, technological, economic, political, or governmental circumstances (UNHCR 2019). Some of these informal settlements are no longer seen by the local populations as "temporary," and they frequently act as a fuel for tensions between them.

Located in Middle East, Lebanon is well known to host refugees from neighboring countries hit by long-lasting conflicts and wars. In Eastern Lebanon, a population of Syrian refugees came after the Syrian conflict that began in 2011. The United Nations High Commissioner for Refugees [UNHCR] reported that in 2019 there were 5,715 of informal settlements with as many as 272,907 people living in 48,105 tents. Figure 1 (left) shows the distribution of the informal settlement throughout Lebanon (source: UNHCR data). The highest share of informal settlements is present in Bekaa with 41.56% of the total population residing in them. The high informality and influx of population observed in this particular area leads to dense settlements with low to no service alternatives leaving the refugees exposed to multiple risks. These refugees are people who had to leave their own country due

to a political conflict and situation of war. Lebanon had previously hosted refugees in Palestinian camps, 70 years ago. These Palestinian camps were observed to become permanent through transitions, to avoid a similar situation, the Lebanese government, formulated a no-camp policy, which meant that the nature of the settlements could not be that of a permanent settlement. As a result, Syrian refugees have now been spread out across the nation and are mostly on their own. More than a third of such population reside in the eastern Lebanon's Bekka valley. This area is primarily agricultural, has substandard infrastructure, and a weak economy. The landscape is marked by shanties. The temporary structures, which are dotted throughout formerly agricultural area, are built of wood and plastic tarpaulin. The occupants pay rent, while some property owners provide them a free stay (Naggar 2020). The present study, examines the living conditions and status of such population living in the Bekaa Valley. For the purpose of context, Zalhe district has been chosen in the valley to look more closely at some of the more local challenges.

Present challenges

The informal settlements of the Zahle district face challenges pertaining to the unplanned growth and organic development of informal settlements, climate-induced disaster risk, shelter, physical and social infrastructure services and economic independence with respect to livelihood in the settlements. The paper aims to give an overview of the present situation of all these aspects and subsequently present a model for a camp design that addresses the category-wise challenges of the settlements.

Unplanned and organic growth

The region under investigation was once utilised for farming over a ten-year period before becoming a camp for refugees. In fact, in a haphazard fashion, communities began to spring up throughout the entire municipal boundary. According to information obtained from the UNHCR's Lebanon Information Hub, 13% of the shelters in the Dalhamieh camp did not meet the required requirements.

Only 15 self-built shelters could house the 85 occupants. As illustrated in Fig. 2, the refugees who live in these shelters struggle to find basic social and physical comforts as per the Lebanon information hub dataset. Socio-economic characteristics in the Zahle district of the Bekaa governorate demonstrate an unplanned growth of the entire region over the years. Such unplanned development has deprived people of the basic human requirements while also contributed in degrading the environmental quality of the sensitive Bekaa Valley region.

Fig. 2 View of Dalhamieh informal settlement in East Bekaa, Lebanon (Source: Amid deepening poverty, cash assistance keeps vulnerable refugees afloat. https://www.unhcr.org/lb/11158-amid-deepening-poverty-cash-assistance-keeps-vulnerable-refugees-afloat.html). Credit: UNHCR/Elie Fahed

Climate-induced disaster risk

The organic expansion of the tents with time within the camp increased the exposure to disasters. The entire region is exposed to climatic hazards such as heavy winds and snow, flooding and extreme climatic conditions. As per the data of Lebanon information hub, 2% of informal settlements are under high flood risk, 19% are in moderate risk and remaining are in low flood risk.

Located in the Bekaa Valley, in the district of Zahle (Bekaa governorate) and at the foot of the Mount Lebanon (East Lebanon), the Dalhamiye settlement is exposed to harsh winters. Flood and snow storms regularly affect the informal settlements where refugees have to cope with tough living conditions (Fig. 3).

In January 2019, the Norma Storm impacted the informal settlements of Dalhamiye in the Bekaa Valley (UNHCR 2019a, b; Al Azzawi et al. 2020) and raised again the issue of implementing resilient settlements in vulnerable places for population at risk due to their prior life conditions before a natural disaster. From the 6th of January 2019 and during about two weeks, the storm Norma brought torrential rains, strong winds and a wave of snow with cold temperatures (UNHCR 2019a, b). 850 settlements were reported at risk of extreme weather, 70,000 refugees at risk, 39,900 of which are children (UNHCR 2019b). By the 12th of January, in its final situation report, the Inter-Agency Coordination Lebanon (UNHCR 2019a) indicated that 574 sites or informal settlements and 22,595 refugees were affected. In the Bekka Valley, 350 sites were considered at risk of flooding and/or accumulation of snow by the 9th of January (UNHCR 2019b).

Fig. 3 (left) Syrian refugees walking through the flooded streets of Dalhamiye informal settlement in Bekaa Valley, Lebanon, January 2019. © UNHCR/Diego Ibarra Sánchez ; (right) Syrian refugees removing snow from their shelters at an informal tented settlement in the Bekaa Valley, Lebanon during a blizzard, January 2015. (UNHCR/A.McConnell) (Source: Refugees caught in heavy snow as storms lash Lebanon and Jordan. https://www.unhcr.org/news/latest/2015/1/54ad5ee49/refugees-caught-heavy-snow-storms-lash-lebanon-jordan.html Ariane Rummery UNHCR 2015)

In 2012, the United States Agency for International Development [USAID] defined this region as a peri-urban flooded risk zone (USAID 2012). A recommendation set out that functional levels for buildings (commercial and industrial) should be above flood levels and any new buildings should be avoided. Nevertheless, these safety standards were not implemented (UNHCR 2019).

Following the flooding in January 2019, a field investigation revealed essential key factors that caused damage in the camp. The Inter-Agency of Lebanon (UNHCR) posted and hosted the interviews of the refugees in its website.[2] A video footage shows that the ground was filled with half to one meter of water. A syrian refugee also reported her heater was cold and her wood was wet. The pictures in Fig. 3 illustrate the climate vulnerability that the families are exposed to. Shelter and camp site design should be a priority for Bekaa valley with its extreme vulnerability towards climate extremes.

Shelter

The unplanned growth and continuous surge of climate-induced disasters has adversely affected the shelter quality in the settlements which are informal in nature. UNHCR status reports and Lebanon information hub, reveal that there is are substandard temporary shelters made with rods and sheets in the settlements which are highly vulnerable to the above-mentioned risks. There has been reports that no measures are taken with respect to the flood risks as per the Lebanon information hub. There are leaking roofs and existing documentation points out at the inundation of shelter floors during floods such as that of 2019. There are also organic shelters with no community resilience and thus after such disaster events the community is generally not able to build back itself or come back to normalcy in a short period of time (UNHCR 2019). There are limited civic services present in the shelter. In the Bekaa, about half of the households reside in overcrowded shelters (less than 4.5m2per person), and nationwide, one-third of the Informal Temporary Shelters (ITS) shelters fall far short of standards for things like weatherproofing, heating, ventilation, and fire danger. The effects on people's health and wellbeing are significant (ADAMS 2018).

Physical and social infrastructure availability

About 45% of the homes used dumpsters to dispose of their trash in Bekaa Valley informal settlements. The information reveals a widespread lack of wastewater and solid waste management, which probably affects the frequency of pest issues and enteric infections [ILO 2019]. The refugees who live in these shelters struggle to find basic social and physical comforts. For a population of 7436, there are just 1075 public toilets. Only 2% of the population's water needs are covered by a formal water delivery network, leaving 78% of the entire population relying on water trucks, and 21% using borewells. Additionally, the Bekaa valley's growth in informal settlements and the unexpected arrival of fresh migrants exacerbated the country's solid waste situation to alarming levels.

Grey water from each tent's bathroom, laundry, and dishwashing area is routed outside via a pipe or open channels. To collect the wastewater, a small, open

[2] Storm flooding brings misery to Syrian refugees in Lebanon. https://www.unhcr.org/news/latest/2019/1/5c386d6d4/stormflooding-brings-misery-%20syrian-refugees-lebanon.html Edith Champagne and Houssam Hariri UNHCR 2019a, b

soakaway pit is typically dug close to each tent. These are frequently too small to let all the wastewater infiltrate, thus they must be manually emptied, with the contents dumped into the closest drainage channel or onto a flat surface. Because of their consumption patterns, ITS households generate a lot of domestic garbage. Few settlements have access to waste bins provided by municipality and collected by them, however many do not have this access due to no provision on bins, charging of fee for bins and collection. In such cases it was observed that the residents resorted to either dumping or burning the waste in areas outside the immediate settlement (ADAMS 2018).

Economic status and livelihood situation

In June 2019, the International Labour Market [ILO 2019] published a well-documented report that highlighted the complexity for Syrian refugees to survive in these settlements with their basic rights fully respected. An analysis of the socio-economic conditions in the Bekaa (ILO 2019) revealed the challenges in planning of the camps considering the needs of the families.

Due to its large fertile plain, the Bekaa valley is the country's main agricultural region. Therefore, many Syrians living in make-shift tents settled there to find employment in the agricultural fields (ILO 2019). The household expenditure of the refugees in the entire Bekaa valley is majorly on the food, debt repayment and the health services. Zahle in particular has household expenditure as 37% of the expenditure in food, 14% in debt repayment, 7% on health services, and the remaining in electricity, transportation, soap, fuel and clothing as revealed by a survey in the same report as shown in Fig. 4. A high expenditure pattern in food sector is attributed to high food insecurity in the region. The report by ILO in 2019 showed a 76% of food insecurity in Zahle which was high compared to the other districts, indicating to a need for intervention at community level.

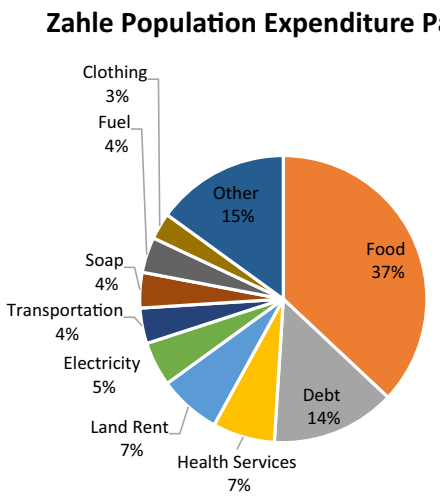

Fig. 4 Distribution of the expenditure in the district of Zahle (Bekaa) (Source: ILO 2019)

The ILO (2019) also reported that while the total surveyed population consisted of 12,708 individuals, 29% of the population was aged between 18 and 49 years old, 5% was aged between 49 and 65 years old, 1% was older than 65 years old and the rest was aged below 18 years old. Moreover, on average, households were comprised of 6 to 7 members in the Bekaa. In the district of Zahle, in particular, 12% are 1 to 4 members, 24% accomodate 5 to 6 members, 47% were 7 to 9 members and 17% include more than 10 members. Finally, in Zahle, 52% of the population is female and 48% is male. Hence, education, healthcare and employment are the main concerns to fulfill the rights to decent income and livelihood. Added is a challenge of refugees not being registered (ILO 2019) which further limits their prospects of getting a formal job.

Resilient camp design model

Several approaches to better adapt and design the temporary life in camps have been proposed so that a resilient settlement with all requirements necessary to meet the needs of all refugees could be implemented. Today, a broad inventory of factors (social and climatic) for resiliency is considered more, as guidance for building and designers (Peters 2021). For refugees and life camps, Maslow's pyramidal hierarchy was the core of many humanitarian's architectural projects (Uysal et al. 2017; Al Azzawi et al. 2020). The lack of the fundamental rights for security and sanitary rights (internal risk factors) contributes to making the refugee population highly at risk in case of a natural disaster because of its exposure (flood, hurricane, earthquakes, etc.). Figure 5 below recapitulates the main points that must be considered while examining all geographical, socio-economic and scientific (natural hazards, resilient engineering architecture design) aspects and factors for a sustainable and standard camp or settlements for refugees. It also shows how resiliency can be achieved at different scales in a settlement, starting from individual level to the entire camp level. The hierarchy of needs, which is the basis of human needs and aspirations, can be modified and seen as a hierarchy of needs for refugee camps. The concept of resilient design model tries to address both the internal risk factors and the external risk factors while keeping in mind the hierarchy of needs and the spatial order of most efficient application of the strategies that can be introduced in an emergency refugee camp design. The model shows the various spatial scales (from "a" which represents an

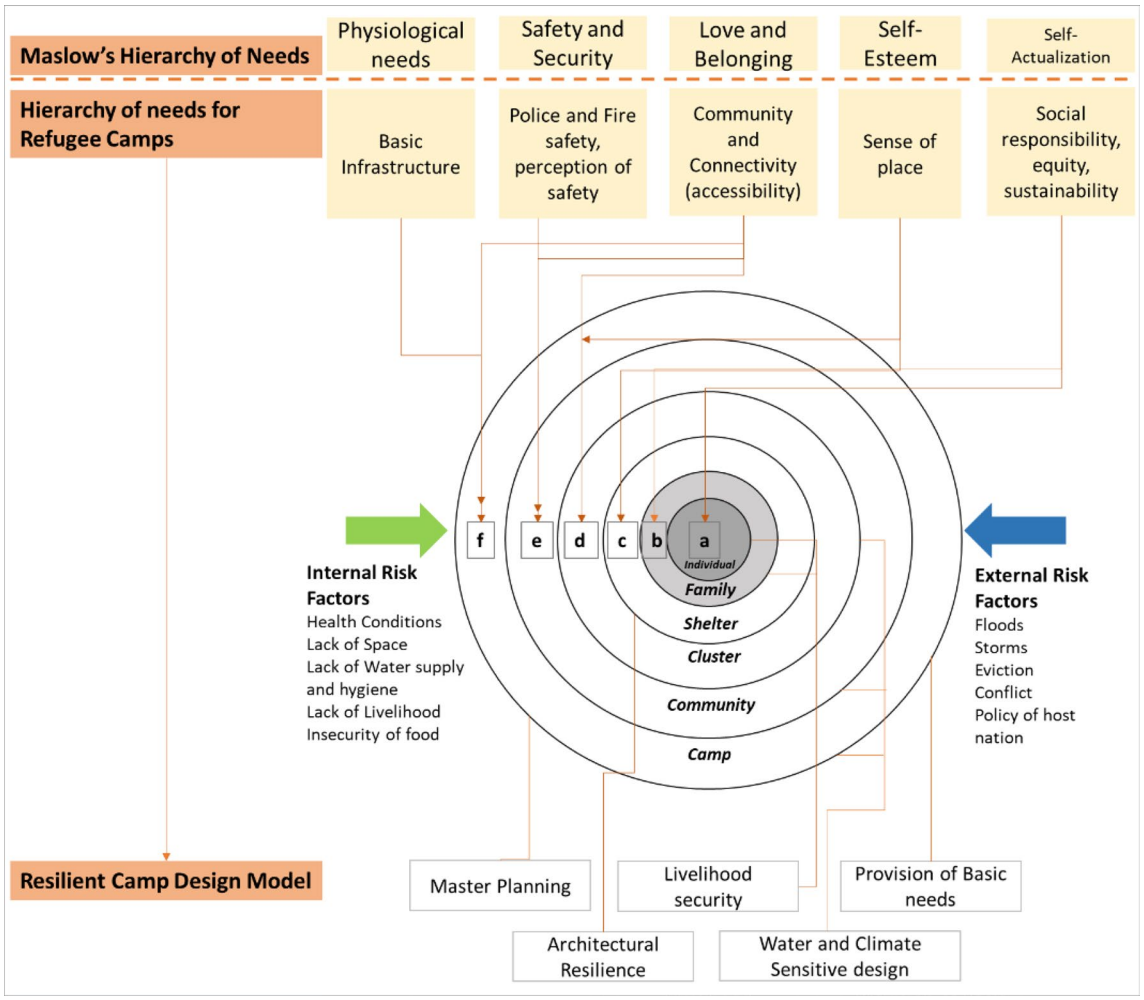

Fig. 5 Resilient Design Model (Source: Author)

individual to "f" which represents the camp). The first part of the model lays down the basic human needs hierarchy, which is scaled up to a settlement level through the basic infrastructure, safety and security, community and connectivity along with accessibility, sense of place and social responsibility, equity and finally sustainability. The connections in the model show how various settlement needs correspond to various scales. Ultimately the resilient strategies also are applicable at multiple levels while responding to the risk factors and the needs of the camp.

Application of the resilient design model

In this work, the design was mostly based on the UNCHR criteria (UNHCR 2000). Table 1 hereafter indicates all the parameters considered in the study for the design intervention in the camp for resilience (UNHCR 2000; Al Azzawi et al. 2020).

Master plan: addressing the unplanned and organic growth

The proposal is to accommodate a population of 7500 in the camp settlement in a planned way as per the existing demographic and socio-economic status of the studied area. The land use planning has demarcated specific zones for residential, commercial, agricultural and utility zones. The internal planning concept of the residential zones have been discussed in the next sections. The master plan provides community education and health care facilities along with a provision for expansion of the camp as and when required as shown in Fig. 6. The design will play an important role in maintaining the socio-cultural cohesion in the community. The flexibility in plan will create different buffer spaces, between public, semiprivate and private areas.

Table 1 Summary of Design intervention in camp for resilience (from Al Azzawi et al. 2020 and after UNHCR 2000)

Parameter	Existing issue/challenge	Proposed strategy
Provision of rainwater harvesting (RWH)	No provision	Yes—RWH pipe in each shelter unit
Ground Water recharge	No provision	Yes—Through RWH pipe and drain pipe for water in shelter during a flood
Basic unit design	Substandard temporary shelter made with rods and sheets	3 m × 7 m for a family of approximately 4–6 members with 3.5 sq. m/person
Installation	Assembled on site	To be received as components and assembled on site with simple steps
Flood resilience structural measures proposed	No measures taken, leaking roofs, inundation of floor during floods	Shelter will be 1 m elevated from the + 0.0 ground using corrugated flexible RP sheets stacked in a honeycomb (HC) cells
Resilience at community level	Organic shelters with no community resilience. Limited civic services present in the shelter	Provision of 30 sqm for basic requirements roads, foot paths, educational facilities, sanitation, security, firebreaks, administration, water storage, distribution points, markets, storage of relief items and, plots for shelter
Health resilience in camp	Limited service available	The common Toilets and washrooms are very important and should be adequate for the indented camp population to avoid open defecation and related health impacts
Community resilience	Limited service available	Community space: Health (physical and mental) and education centers. Self-help groups and livelihood options. Community playground is essential for children to play and for people to come to a place and communicate and support each other
Energy	99% dependence on grid	Installation of solar roofs on community places, shaded areas in agricultural area to reduce the dependence on grid by 30%
Water	Water supply majorly (78%) through trucks	Water recycling, rain water harvesting and water rejuvenation along with ground water recharge to reduce the dependence on external water trucks and the cost associated with the same
Solid Waste	75% collection by municipality	Increased recycling and re-use of waste. Segregation and management included in the livelihood action strategy to reduce the waste generated within the community. Concept of sustainable consumption and production recommended
Recreational Spaces	No attention to recreation in overcrowded high density settlements	Hanging gardens designed in each unit along with common play areas and vegetable garden for the utility and recreation of the community

The table summarizes the existing context pertaining to elements of camp design and the strategy proposed in line with the resilient model. The subsequent sections elaborate on the key strategies as proposed in the resilient design model. These strategies are put forth as guidelines to enhance the coping capacity of the settlements and improve the quality of life of the settlements

While planning the internal arrangement of the residential zone of the camp plan, cluster planning has been included to serve privacy to the families. This can connect one family with more than 4 members in one cluster where the cousins and relatives stay together and spend the outdoors activities together. Also, they can be independent in the same time on their own private shelters. Moving from micro to macro view, the benefit of the shelter flexibility design is here well illustrated, with an additional contribution for the urban design. The cluster shapes can go to "S" or "O" according to the study of the winds in the area occupied (Fig. 7).

Climate sensitive design: addressing the climate-induced risks

The built environment design and the master plan of the entire site is proposed to safeguard against the climate risks. The location of new site is proposed to be in the low flood risk zone of the river Litani. This will ensure that river flooding does not happen in the settlement. For managing the stormwater several design principals like rejuvenation ponds, rain water harvesting, green infrastructure to maintain the permeable surfaces in the entire settlement have been planned strategically keeping in mind to not just protect again floods but also use rain water as a major resource of water for the settlement.

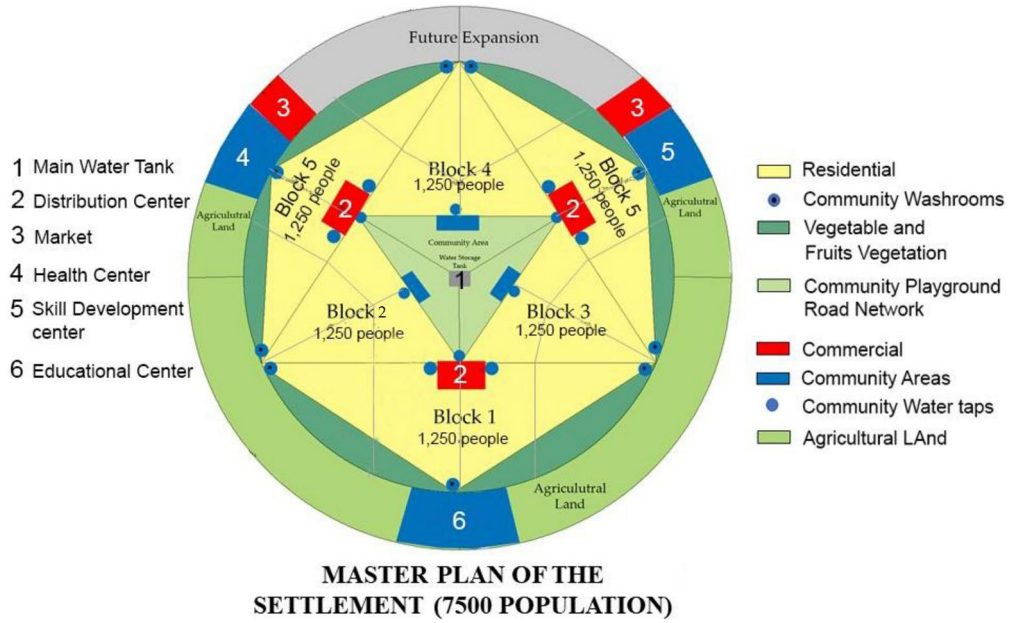

Fig. 6 Master plan of the settlement (7500 population)

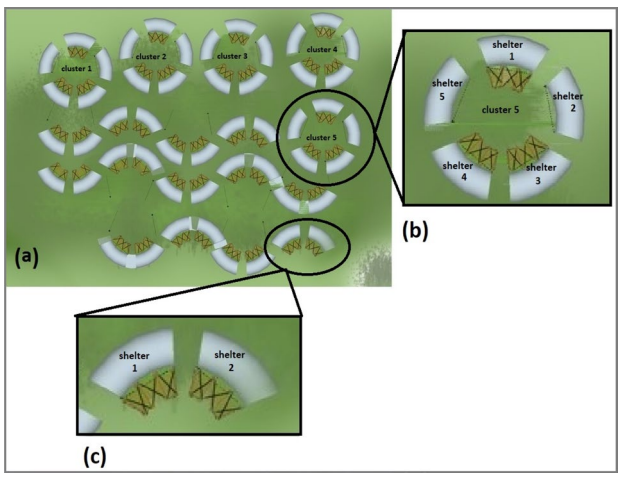

Fig. 7 Internal planning of residential zones of the camp plan

Internal housing design is also done keeping in mind the various pressures of the environment as described in the next section.

Resilient shelter design: addressing low-quality housing

In this study the design considered several foundational aspects that will hold the structure stand still avoiding collapsing. First aspect is the relation between the shelter body and the environment, how the design can stand in the high wind intensity pressure. The study compares between the basic shapes and how they react to the wind pressure. When the surface area of the face of the structure meets with wind force with high area surface as shown in Fig. 8a, it generates bigger force to push forward and affect the stability of it. For the triangular side the velocity of the wind doesn't face a reaction because it slides and flow smoothly upward, as shown in Fig. 8b. Finally the circular also distributes the wind flow from all sides as shown on Fig. 8c.

As to enhance the above theoretical study, literature shows how even circular surfaces are used to lower the force of the wind on the building and preventing it from destruction or deflection. In particular, wind load has been tested for comparison on sharp and circular surfaces through simulation with the software SimScale (Fig. 9).[3] The results showed the circular was the safest solution (Fig. 8 and 9).

The structure of the honeycomb for shelter's design is particularly suitable for low-density and high-strength materials. It is as well well-known for its anti-penetration effect (Wang et al. 2016). Moreover, the building shape helps in preventing damage from natural hazards (Alvarez 2020). In the concept study (see Fig. 10), the shape of the shelter was examined to minimize the wind pressure. Flexibility is also one of the main key parameters when designing the individual shelters. Hence, the shelter structure is to be flexible. Honeycomb to be strong to withstand and be used and its flexibility will give it

[3] How to Calculate Wind Load on a Building. https://www.simscale.com/blog/2017/05/wind-loads-buildings/ Anastasia Churazova June 14th 2021.

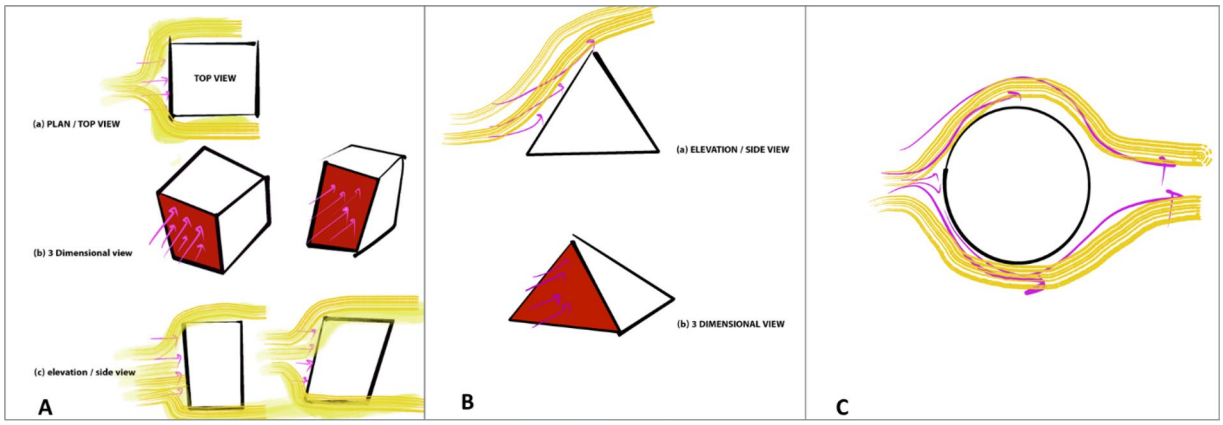

Fig. 8 **a** Effect of lateral load on square fixed structure; **b** Effect of lateral load on Triangular fixed structure; **c** Effect of lateral load on circular surface

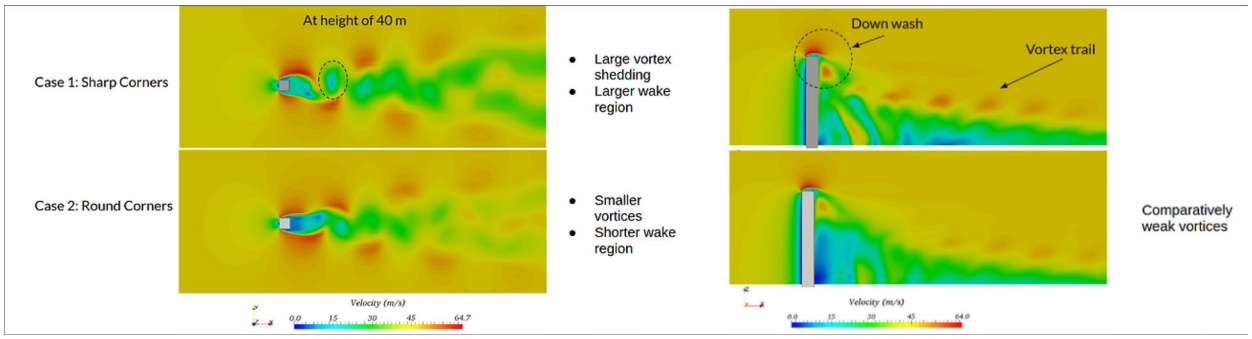

Fig. 9 Wind Load Calculation on a Building with Computational Fluid Dynamics (CFD) (Source:) See Foot note link 3

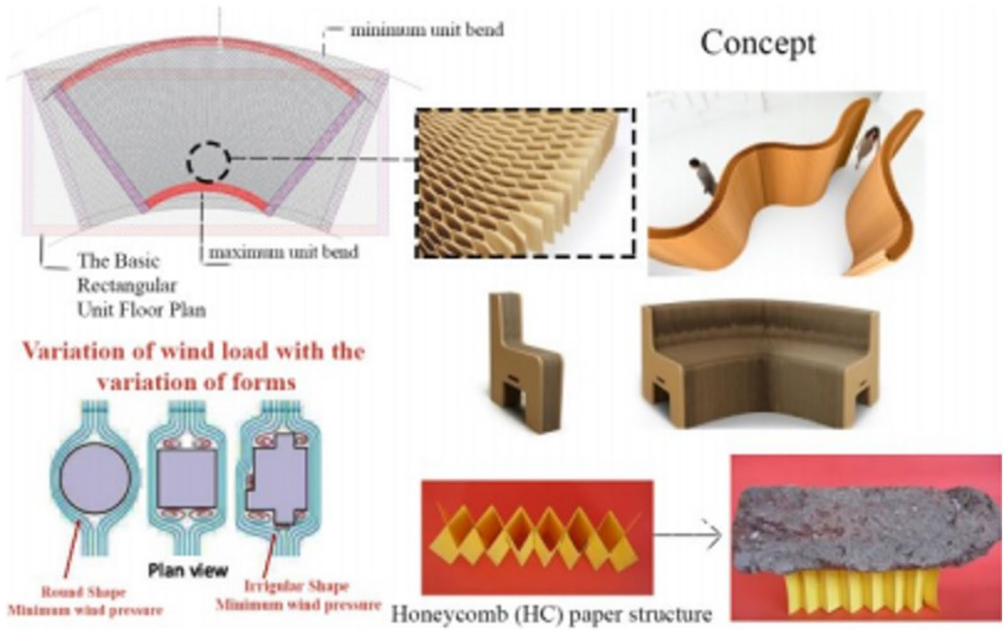

Fig. 10 Concept study summary for the shelter design

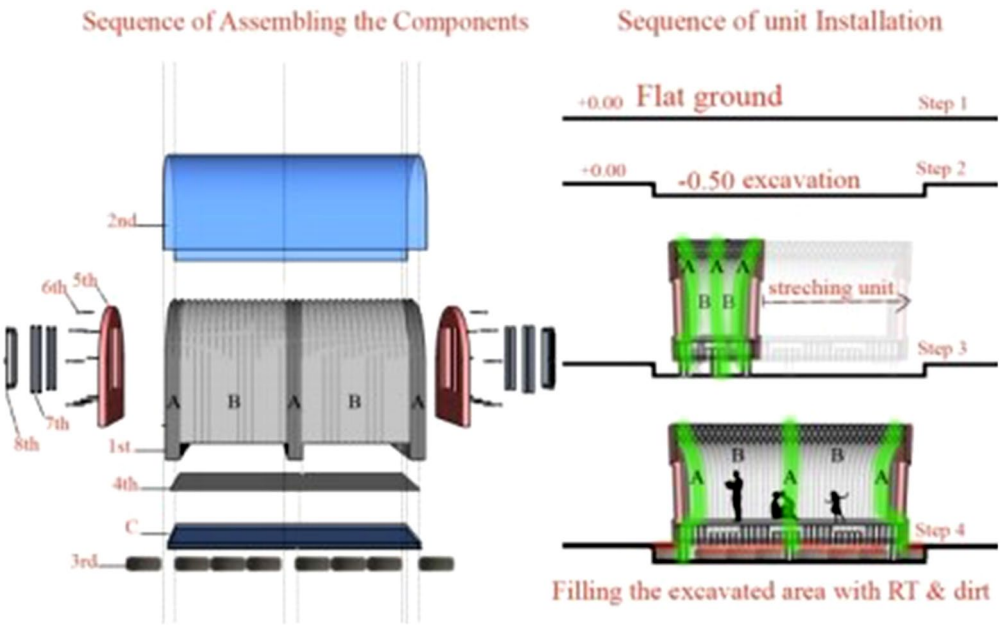

Fig. 11 Sequence of assembling of the cluster (left) and sequence of unit installation of the cluster (right) (Source: Al Azzawi et al. 2020)

the opportunity to create variety of organic circular shapes that can be used according to the shelter location situation. The shelter will be almost global use; it is not designed to one specific area. For example, if the area has strong winds, the owner can fix the shelter as curved or the camp can create together a huge circle that protect the internal entire camp from being affected or getting destroyed. Figure 11 presents the sequence of assembling and unit installation of the cluster after (Al Azzawi et al. 2020).

The strength of the paper structure is here illustrated by using the honeycomb shape. The flexible basic shape permits the freedom to design according to specific needs and environmental purposes.

It is crucial for the community to be able to build and assemble the structures in the community with ease and lesser outer dependency. Thus, the design provides an assemblage strategy with details of each component represented in Fig. 11.

First stage is the first structure contains (A) the rigid part that acts as the backbone of the shelter and (B) the flexible part that the owners can have, e.g. a curved or rectangular shelter according to the needs. The second component is a plastic sheet cover that gives smoothness against the wind followed by recycled tires that are used as shelter foundation and wooden sheets that cover the hexagon structure for having slab to walk and function. Then fifth is the front and back cover of the shelter with doors and window opening along with screws that are used to fix the front and back cover and then there would be windows and doors.

The assembling of the units includes 4 basic steps which are: (step 1) ground to be flattened; (step 2) excavate 50 cm under the ground; (step 3) shelter to be allocated then stretched to the full length; (step 4) people can use it (Fig. 11).

Physical and social infrastructure: addressing low service provision and management

Health care center planned in the settlement is proposed to function in much the same way with a dedicated skilled sector of production of medical supplies which can be manufactured at the camp site for general medical use. The health center is also proposed to have a medicinal plants garden to produce ingredients for immunity booster home remedy solutions to ensure a long-term healthy settlement not dependent on external medical supplies to a significant level. Production of masks, face shields, napkins etc. would be promoted at the health center to generate economy, employment and supplies in the camp. The same supplies can be sold in nearby camps during an increased supply situation to enhance the local economy.

To enhance the cultural aspects of the shelter design, in which privacy play huge part in their community, local gardening will be designed in a way that will create a mini garden to each family and a private area for outdoor sitting area. These both will improve the mental and psychological state of the families. Hanging garden will give

Fig. 12 Community farming section

the family the opportunity to plant more than a small part, surrounding the shelter, and it will create an aesthetic view (Fig. 12). Considering beauty and aesthetic elements play a big role in making a better community with better mental state as part of any human right, as mentioned in Maslow's pyramidal hierarchy.

Having a garden means needing water. The water management is examined through the tank to the community water taps and the community washrooms. Separate lines for the community toilet are to use only recycled water in toilet flush. The used water from the washbasin would directly go to the flush. The water from the bath and cloth washing would be drained through treatment drain pipes as shown in Fig. 13. Community toilets are proposed to have recycled water to manage the usage of water more effectively in the settlement.

When gardening, in summer, to prevent from water evaporation, a rope could be connected between the plant on each plastic pot and connect it to a covered water bottle. This method will transfer water equally to all plants without any loss.

Table 2. provides an overview of the infrastructure planning suitable for a camp setting. Limited resources need full and efficient and sustainable planning and management to be able to effectively and sufficiently provide for the basic needs of the community. Thus Table 2 aims to present a strategy to resolve the lack of water supply and sanitation challenges in the informal settlement through the concept of water sensitive planning of the neighborhood to increase the groundwater-sensitive water recharge potential of the neighborhood. The Table 2 below provides full details for the water management engineering process. As per UNHCR norms, we considered the water requirement was 20 L per person. Thus, the total water requirement for the population of 7500 people is 1.5lakh liters with a water tank of 200 m^3. Presently, 86% of the non-permanent shelters in Bekaa valley have access to grid electricity.

Sustainable economy and livelihood: addressing the challenges of lack of livelihood

Along with the placement of activities the master plan also proposes various aspects of the socio-economic functioning of the camp. Economic sustainability is a higher order need of human, along with the settlement requirement. This economic sustainability has been addressed in the design model through strategies pertaining to security of livelihood and cost saving on the various expenditure avenues of the population through local level actions. In order to reduce the expenditure on the food (which accounts to 37% of the total expenditure), the proposal is to increase internal camp farming to produce local food supplies. Individual families can have small vegetable gardens for fruits, vegetables and herbs. At community level, the entire settlement has dedicated farm areas which can be further subdivided as fruits,

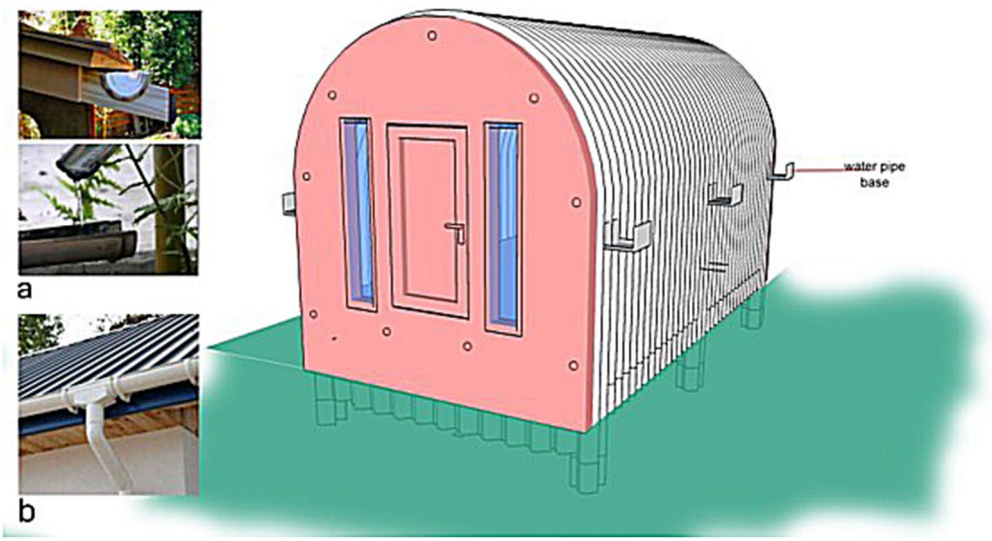

Fig. 13 Water pipe with base in the shelter (removable to clear dust and snow)

Table 2 Physical Infrastructure Status and Recommendations

Networks	Present status	Recommendations	Material and method
Water supply	High dependence on external trucks and ground water	Integrated water sensitive urban planning in the neighborhood	Through the tank to the community water taps and the community washrooms. Separate lines for the community toilet to use only recycled water in toilet flush. The used water from the washbasin would directly go to the flush The water from the bath and cloth washing would be drained through treatment drain pipes
Sewerage network	Lack of waste water treatment	Integrated planning for waste water management to capture maximum recycling potential	The waste water will depend on the local materials such as pipes that can be bamboo pipes or PVC or any available local material • The filtration process can be a multi filter process with screens for multiple diameters • Local community would maintain the waste water treatment plants • Grey water pipes to be treated separately for recycling (three step process—Screening of effluents in sewage, Adding alum and lime through an aeration process, Filtration and chlorine dosing. Recycled water to be used in toilet flushes, road washing etc • Black water to be treated separately
Rain water pipes	No consideration, water logging after rains	Rain water harvesting through sustainable materials	Bamboo pipes with sub branches—one to the shelter and second to the ground water recharge pit
Recycled water rejuvenation ponds in agricultural land	No consideration for water in the planning	Rejuvenation ponds in agricultural land. Limit on ground water extraction	Water rejuvenation ponds in the agricultural land • Rain water collection • Filtration of waste water to recharge ground water • Water condensation pits to generate water year long without extracting ground water
Solid waste management	No consideration, situation worsened by frequent flooding clogging the waste and becoming a health hazard	Solid waste management through recycling, reusing and waste to wealth strategy	The solid waste has been seen as a resource and concept of circular economy has been applied by proposing recycling center in the community for active resident participation in the process of utilizing waste, waste segregation and reusing

vegetable, cereals etc. The sub division would also allow for farming activity scheduling and man power division as per the skills and demand. Dependency on packaged food items would reduce with such community farming solutions. Main crops in the region are potatoes, grains, fruits & vegetables thus an emphasis on local community kitchens to feed the people, community gardens that would be looked after by people and managed by people themselves. Agricultural activities include processing, packaging and distribution to nearby camps and settlements to create a self-sustainable economy, which can strengthen the livelihood even further. A section of the community kitchen is proposed to create food packets using sustainable materials like recycled food boxes, leaf boxes (also manufactured at the camp) and the delivery of the same to nearby camps and shelters.

The distribution center is proposed to include a recycling and package material production center. This center would employ around 10% of the unemployed population of the camp including those who are working in the agricultural sector but are workless due to seasonal attributes. Sustainable materials such as recycle paper (paper mache), big leaves etc. would be utilized. The same center would produce planting pots using used plastic bottles and other plastic waste. The recycling center would cater to the demand of materials (essentials and decoration) for the camp along with reduction in the waste generation at the camp. A circular approach towards consumption and production of goods is proposed for the camp in order to maintain the livelihood along with managing and reducing the waste in the camp.

Conclusion

The proposed resilient design model is a preliminary design umbrella strategy which can be modified and altered as per the settlement population, site constraints and general resource availability. The model itself presents external and internal risk factors, which are highly contextual in nature. The recommendations thus provided by authors are not a rigid structural plan but a strategic, data driven set of actions that can be implemented by the local refugee community in order to achieve greater resilience and self-sustainability during crisis situations. Such model is applicable with modifications for other emergency settlements also with varying risk factors. With increased mental stress that the refugees live with, a constant environmental, physical and economical threat that they are exposed to, is required to be reduced and reinforced with the concept of resiliency at all levels. Thus, the proposal provided aimed to achieve a comprehensive set of solutions keeping in mind the limited resources available within the community. The proposed model addresses the challenges and the multiple risks that the people are exposed to present a framework that can lead to better quality of life in temporary settlements also. The context, pattern, culture, socio-economic standing and aspirations of the people were all studied and incorporated in the model to present a holistic solution to a challenge which may soon increase not just in Lebanon but globally. With more climate refugees, conflict driven refugees and internal refugees, absence of such models was a gap and the authors have tried to build the same through one case study.

Acknowledgements
The authors acknowledge the valuable inputs given by anonymous reviewers of the paper who have contributed to enhancing the quality of the paper.

Author contributions
Author PT: Contributed in writing the draft, editing the manuscript and generating maps and other community analysis, master plan and resilient model development, author NA: Contributed in shelter design development, visualization and description of shelter, Author LA: Contributed in formatting the manuscript, supervising the research and writing the draft. All authors read and approved the final manuscript.

Funding
Not applicable.

Availability of data and materials
The data used for the research is available as open source data at the mentioned sources.

Declarations

Competing interests
There are no competing interests in this research.

Received: 26 August 2022 Accepted: 21 November 2022
Published online: 09 January 2023

References

Aburamadan R, Trillo C, Makore BCN (2020) Designing refugees' camps: temporary emergency solutions, or contemporary paradigms of incomplete urban citizenship? Insights from Al Za'atari. City Territ Archit 7:12. https://doi.org/10.1186/s40410-020-00120-z

ADAMS J (2018) A clean and decent life Without wash? the impacts and risks of reduced wash funding for Syrian refugees in Bekaa, Lebanon. Oxfam Research Reports. https://doi.org/10.21201/2018.2951, https://policy-practice.oxfam.org/resources/a-clean-and-decent-life-without-wash-the-impacts-and-risks-of-reduced-wash-fund-620506/

Al Azzawi N, Tiwari P, Amir L, Mushtaha E S (2020) Sustainable and resilient design for emergency shelters in flood risk community. In: IEEE 2020 advances in science and engineering technology international conferences (ASET)—Dubai UAE United Arab Emirates (2020.2.4 2020.4.9). https://doi.org/10.1109/ASET48392.2020.9118276. https://ieeexplore.ieee.org/document/9118276

Alvarez R (2020) Resilient architecture: consider building shape, https://mitigat.com/2020/04/16/17/50/42/resilient-architecture-consider-building-shape/

Bashawri A, Stephen G, Krisen M (2014) An overview of the design of disaster relief shelters. Procedia Econ Finance 18:924–931. https://doi.org/10.1016/S2212567(14)01019-3

Ezezue A, Akachi V, Obiadi B, Kelechi A, Kikanme E (2019) Designing for emergency shelter for displaced persons in nigeria: nimbo as an example 10 75–87. https://www.cepajournal.com/
ILO (2019) Survey on child labour in agriculture in the Bekaa Valley of Lebanon: The case of syrian refugees, 104 p
Naggar M (2020) Informal refugee settlements. Retrieved from D+C Development and Cooperation: https://www.dandc.eu/en/article/syrians-living-lebanons-informal-refugee-settlements-lack-proper-infrastructure
Peters T (2021) The Social Context of Resilient Architecture. In: Michael U (ed) Multisystemic Resilience. Oxford University Press, Oxford. https://doi.org/10.1093/oso/9780190095888.0030033
UNHCR (2000) A Handy Guide to UNHCR Emergency Standards and Indicators, Geneva, 2nd edition, 41.
UNHCR (2019) Emergency handbook: Shelter in urban areas.
UNHCR. (2019). Vulnerability Assessment of Syrian Refugees in Lebanon. UNHCR.
UNHCR Inter-agency coordination lebanon. norma storm: situation report—12 January, 2019a.
UNHCR Inter-agency coordination lebanon. norma storm situation report - January 2019b.
USAID (2012) Litani river flood management support program: Litani river flood management report.
Uysal H T, Aydemir S, Genç E (2017) Maslow's hierarchy of needs in 21st century: the examination of vocational differences. In: Arapgirlioğlu H, Elliott R L, Turgeon E, Atik A (ed) Researches on Science and Art in 21st Century Turkey, https://www.gecekitapligi.com
Wang Q-F, Shi S-Q, Chu Z-J, Sun J-H (2016) A study on the anti-penetration properties of a biomimetic hexagonal honeycomb shelter. Arab J Sci Eng. https://doi.org/10.1007/s13369-016-2103-9

Publisher's Note