The architecture of refugees

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Abstract: It is widely known that global warming could lead to a humanitarian crisis. In fact, the environmental and climatic conditions needed by people to survive are being increasingly disrupted. Europe is facing the worst displacement crisis since World War II, according to the United Nations High Commissioner for Refugees (UNHCR). There are more than 68 million refugees living in camps in harsh environments and extreme climates. Shelters provided are mostly inadequate due to several factors, such as space, privacy or culture. In addition, the thermal performance and the conditions inside shelters could cause health problems such as thermal stress or, in the worst case scenario, they could lead to death. This is an extremely important task, as we need a quick scalable housing solution that can create a space that meets comfort conditions in the face of a crisis of unknown duration. Thus, this research is focused on the assessment of thermal conditions in shelters from different climatic zones: Jordan, Afghanistan and South Sudan, and it also explores the possibility of achieving better results in a different country; following a previous study of the conditions in each country in order to fully understand their basic needs.

Keywords: Refugees, shelter, thermal stress, health risks, privacy and cultural safety

1. Introduction

Desertification and the consequent natural disasters threaten to change today's demographic map, according to a report by Christian Aid (Aid, 2018), which claims that one billion people will be displaced from their homes by 2050 as a result of climate change.

This problem began to get worse shortly after the end of World War II, and since 1970, it has resulted in millions of newly displaced people every year, according to UNHCR (UNHCR ACNUR, 2017). This annual report shows that multiple displacements characterized 2017, as the number of displaced people increased to 68.5 million, compared with 65.6 million in 2016, which means an average of 31 people being forced to flee their homes every minute, either across borders or within their own country.

These people, known as climate or environmental refugees, are facing a legal, political and social vacuum (Otto, 2017), as this term is not legally correct. International law does not recognize the climate or environmental refugee status and the definition of refugee does not include people displaced for environmental reasons.

According to the World Bank, unless action is taken, up to 86 million people could be displaced in Sub-Saharan Africa by 2050 due to climate change (EuropaPress, 2018).

More than half of those suffering this situation are children between 0 and 17, who account for 54% of people in refugee camps, according to available data from UNHCR (UNHRC ACNUR, 2017). It is important to bear in mind that 173 000 children fled unaccompanied by their parents or another family member who is of age.

The challenge posed by climate change, which causes those refugees to be displaced, makes it necessary to provide a proper response regarding shelters, at least as a temporary emergency solution.

The problem lies in the inappropriateness of shelters provided to those people. This is firstly due to factors such as space, habits or culture, since, as shown by Manfield's surveys (Manfield et al, 2004), the shelter is used, seen and valued differently depending on the ethnic and cultural background of its occupants. Secondly, this is due to the unsolved issue of the monitoring of thermal conditions, the lack of which usually poses health risks, such as thermal stress, exacerbation of diseases or, in the worst case scenario, death (UNHCR, 2017).

Thermal stress is the sensation of discomfort caused by staying in an environment in which body mechanisms must make an enormous effort to maintain its internal temperature. It is the lack of thermal comfort, according to IMF (IMF Business School, 2018).

Environmental (temperature, thermal radiation, relative humidity and ventilation), psychological and cultural, as well as individual conditions (metabolic consumption and clothing insulation) are essential for thermal comfort. If environmental conditions are extreme and individual conditions are not taken into account, we won't be able to counterbalance the heat or cold gained or lost and that's when a thermal stress situation arises.

These situations often occur in the shelters provided due to inadequate thermal conditions, as borne out by one of the baseline studies conducted by Fosas (Fosas et al, 2017), whose results show maximum indoor temperatures over 45°C. This research, located in the Azraq refugee camp (Jordan), managed to reduce internal overheating by 2.3% a year, thus easing thermal stress values.

In cold weather conditions, there have been up to 20 deaths in a single night, as UNHCR warned in 2017 (RTVE, Refugee crisis, 2017). This is due to poor shelters which are neither properly heated, nor prepared to be subject to extreme thermal changes. Rachel Battilana (Battilana, 2001) conducted a research on the design of a cold climate temporary shelter in Afghanistan. The test was performed under normal conditions (without the liner) and with the liner, and the logistical burden for the camp was reduced in the second case.

Taking all the aforementioned quantitative and qualitative factors into account, we are facing an urgent need to provide a temporary shelter solution that is able to offer safety, privacy and comfort. Therefore, this research is focused on evaluating thermal conditions in shelters from three climatic zones, as well as on developing an initial proposal for improvement based on the results obtained.

2. Methods

This research is focused on the assessment of thermal conditions in shelters in Jordan, Afghanistan and South Sudan, as well as on comparing the results obtained in their own countries with those that would be achieved if they were located in the weather conditions in the other two countries.

In order to conduct this research, we analyzed the following aspects:

2.1. Environmental conditions and basis for the analysis

The study was focused on three particular climatic zones: Jordan, Afghanistan and South Sudan (Figure 1). Therefore, a thorough analysis of the geographical and climate framework of each country, as well as their habits and culture and their refugee camps, was performed.

Figure 1. Location of climatic zones assessed.

Geographical and climate framework

Geographically, Jordan is characterized by its arid plateau on the east bank of the Jordan River and the Dead Sea. We focused on Amman, which is characterized by low rainfall, winds of up to 14.3 km/h, an extremely hot summer (with temperatures exceeding 32°C) and a mild winter (between 3°C and 11°C, although in extremely cold days, temperatures may drop below zero) (Weather Spark, 2018).

Afghanistan is a landlocked mountainous country with a relatively dry climate, which varies depending on the altitude and location (Worldmark Encyclopedia of Nations, 2017). In this case, we are in Sozma Qala, with very hot, dry summers (exceeding 34°C) and cold (sub-zero temperatures), dry and partly cloudy winters (Weather Spark, 2018). The most unpleasant features are dryness and dusty winds.

South Sudan is located in East Africa. This research was focused on Juba, where the wet season is very hot and oppressive. Over the course of the year, temperatures vary from 21°C to 39°C. Unlike the other two countries, South Sudan has a high rainfall, with an average precipitation of 142 mm (Weather Spark, 2018).

Habits and culture

Both Jordan and Afghanistan are countries where Islam, the official state religion, molds most customs and traditions, such as Ramadan or Eid al-Fitr. Muslims are divided in Sunni and Shia, and around 80% of Afghans are Sunni.

South Sudan is influenced by Christianity and, unlike the previous two countries, there is not a dress code. They wear lighter clothes in order to withstand high temperatures.

Refugee camps

We focused on the Azraq refugee camp (Jordan), the Gulan camp in Khost (Afghanistan) and the Ajuong Thok camp in Yida (South Sudan).

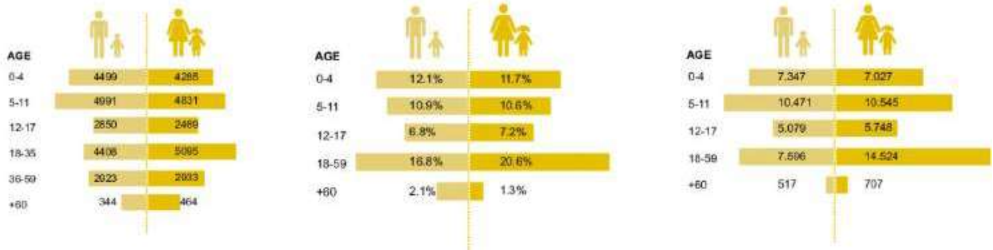
According to ACNUR FACT SHEET, the Azraq refugee camp is currently home to 36 699 refugees in four villages.

Meanwhile, 42391 of all refugees in Afghanistan are registered in Khost, according to the Operational Portal for refugees (Afghanistan, 2018). Most of these people come from the south, where the traditional strongholds of the Taliban insurgency are located.

Finally, the Ajuong Thok refugee camp currently hosts 40 502 people, according to the UNHCR South Sudan Fact Sheet (FACT SHEET SOUTH SUDAN, 2018). It is important to highlight that the majority of refugees in this camp are women, the majority of whom fled from human rights violations.

In most cases, these people leave their homes in search of a safer place, they come from urban settings and they are used to stable living conditions (according to verified statements).

Figure 2 shows the demography of the aforementioned camps.



Azraq (Jordan) **Gulan, Khost (Afghanistan)** **Ajuong Thok, Yida (South Sudan)**

Figure 2. Demography of refugee camps studied.

2.2. Case studies

First of all, it was necessary to know the type of shelters provided, by consulting the UNHCR Shelter Design Catalogue (UNHCR Shelter and Settlement Section, 2016).

This catalogue classifies shelters in four types: global shelters, emergency shelters, transitional shelters and durable shelters.

There are 4 types of global shelters, depending on their lifespan: from tents with a plastic sheeting to shelters having a self-supporting structure, wind resistance and snow loads.

Emergency shelters are classified in 5 types, according to their country. Local materials are often used.

Regarding transitional shelters, there are 3 different types, depending on their location as well. These structures have a longer lifespan and they try to maximize privacy and protect against severe weather conditions.

Finally, durable shelters in Pakistan and Iraq are brick constructions divided in up to two rooms and a living area.

The climatic zones on which this research is focused were selected because of their climate, as well as having the largest refugee camps. On this basis, the case studies are the Azraq T-Shelter, developed in Jordan and classified as a transitional shelter, as well as the Tent Shelter, developed in Afghanistan, and the Tukul Shelter, developed in South Sudan, both classified as emergency shelters.

Figure 3 and Table 1 and 2 show Location 01 that is developed in Jordan

Figure 3. Type 1 shelter

Table 1. Analysis conditions in type 1 shelter.

ANALYSIS CONDITIONS	
Number and gender of people	Family of 4 people (Man, Woman, 2 children)
Metabolic conditions Factor (Man=1.00, Woman=0.85, Children=0.75)	0.84
Clothing	Winter clothing (clo) 1.00 Summer clothing (clo) 1.00
Shelter size	24 m²
Density (people/m²)	0.166

Table 2. Features of type 1 shelter.

BUILDING ENVELOPE		Thickness
Wall	IBR sheeting Expanded Polyethylene IBR sheeting	0.35mm 1.5cm 0.35mm
Roof	IBR sheeting Expanded Polyethylene IBR sheeting	0.35mm 1.5cm 0.35mm
Door	Door cladded with flat corrugated iron sheeting and filled with Expanded Polyethylene insulation.	
Window	Steel window frame. 1m x 1m	
Infiltration	0.70 h^{-1}	

Figure 4 and Table 3 and 4 show Location 02 that is developed in Afghanistan

Figure 4. Type 2 shelter

Table 3. Analysis conditions in type 2 shelter.

ANALYSIS CONDITIONS	
Number and gender of people	Family of 4 people (Man, Woman, 2 children)
Metabolic conditions Factor (Man=1.00, Woman=0.85, Children=0.75)	0.84
Clothing	Winter clothing (clo) 1.50 Summer clothing (clo) 1.50
Shelter size	38.7 m²
Density (people/m²)	0.103

Table 4. Features of type 2 shelter.

BUILDING ENVELOPE		Thickness
Wall	UNHCR Tarpaulin	1cm
Roof	UNHCR Tarpaulin Bamboo structure	1cm Ø 5 cm
Rest zone	UNHCR tent covered by tarpaulin 1cm	
Floor	Tarpaulin 1cm	
Infiltration	0.70 h^{-1}	

Figure 5 and Table 5 and 6 show Location 03 that is developed in South Sudan.

Figure 5. Type 3 shelter

Table 5. Analysis conditions in type 3 shelter.

ANALYSIS CONDITIONS	
Number and gender of people	Family of 4 people (Man, Woman, 2 children)
Metabolic conditions Factor (Man=1.00, Woman=0.85, Children=0.75)	0.84
Clothing	Winter clothing (clo) 0.50 Summer clothing (clo) 0.50
Shelter size	21.6 m²
Density (people/m²)	0.214

Table 6. Features of type 3 shelter.

BUILDING ENVELOPE		Thickness
Wall	Adobe plastering technology Branches of local wooden poles Adobe plastering technology	2.5cm Ø 5 cm 2.cm
Roof	Covered by thatch Branches of local wooden poles	2.5cm Ø 5 cm
Door	Bamboo sticks	
Floor	Tarpaulin 1cm	
Infiltration	0.70 h-1	

3. Results and analysis

3.1. Quantitative results

Each case study was firstly assessed in its own climate and then it was tested in the climatic conditions of the other two countries, in order to determine if a better result could be achieved. Thus, nine analysis of the three case studies were conducted with the tool Design Builder.

In order to run the simulations, regardless of the climate data of each region, a series of specific characteristics and considerations were taken into account for each shelter, such as number of occupants, clothing, shelter size or building materials, as seen above.

Besides, all cases were focused on calculating three main parameters: internal and solar gain, comfort (relative humidity and operative temperature), and ventilation; bearing in mind that the results obtained correspond to the most extreme summer and winter weeks, respectively.

The average results obtained are shown below:

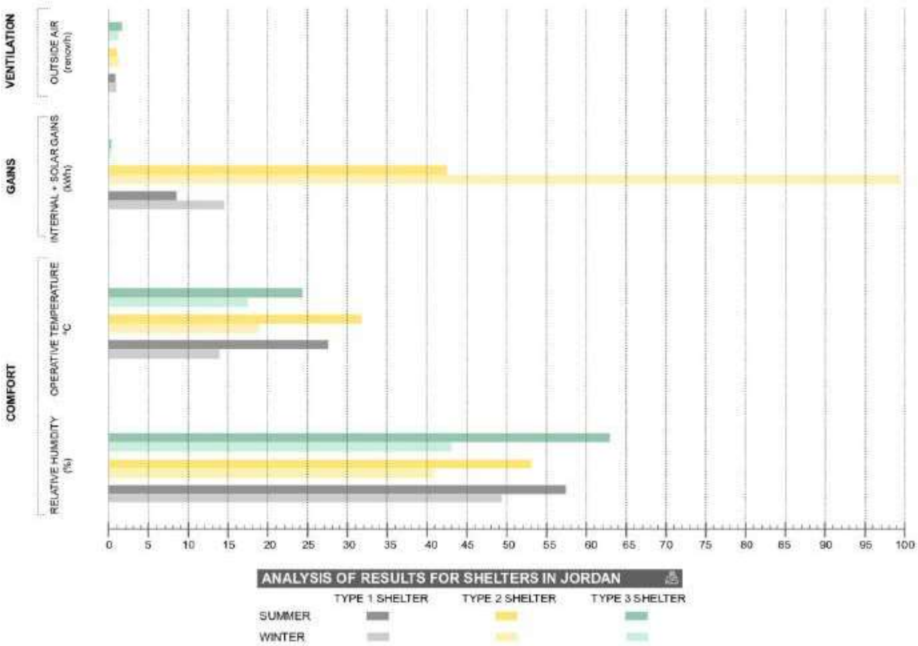


Figure 6. Results obtained from climate data of Jordan.

Figure 6 shows the results for the three shelters analyzed under the climatic parameters of Jordan.

As can be seen, the type 3 shelter achieved the best result regarding the operative temperature, with values ranging from nearly 20°C in winter to 25°C in summer, as opposed to type 1 and type 2 shelters, which reached higher values in summer.

However, the relative humidity in the type 3 shelter was high, reaching a value of 63% in summer. Besides, the solar gain was negligible, although it obtained an outside ventilation of up to 1.96 h^{-1}. As for the other two shelters, the type 2 shelter exhibited a solar gain of nearly 100kWh and the type 1 shelter ranged between lower, more constant values (10-15kWh).

Regarding the relative humidity, the type 2 shelter obtained an average value between 40% and 55%. Nevertheless, the ideal results were undoubtedly those achieved by the type 1 shelter: between 49% and 58%.

Ventilation was one of the most remarkable parameters. Even though it achieved very poor results in all cases, it remained more or less constant both in type 1 and type 2 shelters, with 0.70 and 0.72 h^{-1}, respectively.

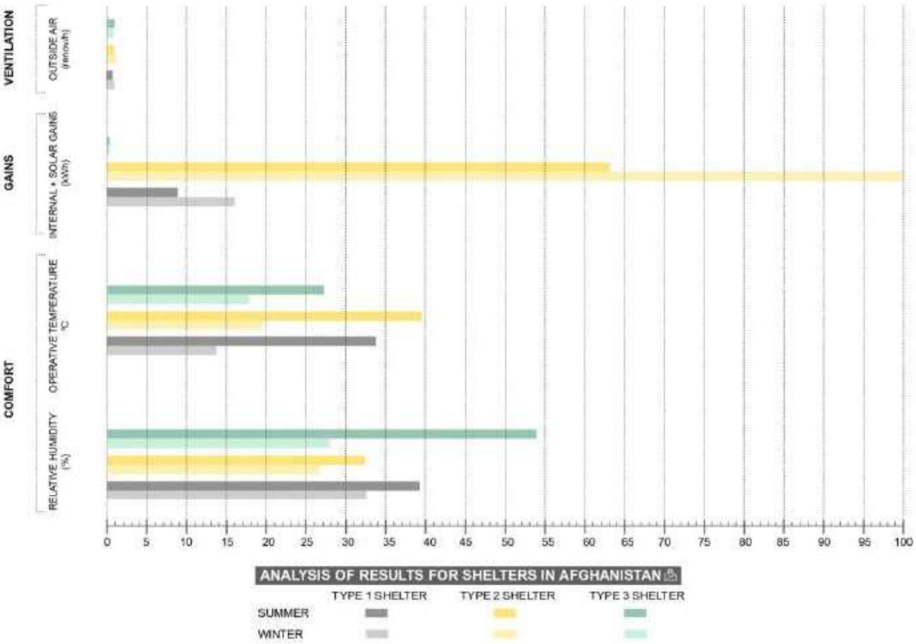


Figure 7. Results obtained from climate data of Afghanistan.

Figure 7 shows the results obtained for the shelters in Afghanistan, and it contains some points that are worth mentioning. The type 3 shelter continued to exhibit very interesting values regarding its operative temperature (18◦C in winter and 27◦C in summer), but its relative humidity decreased too much in winter, down to a 28%. Besides, its solar gain was insignificant.

There were a few similarities between type 1 and type 2 shelters regarding their relative humidity, as they showed values below 40%. Even though their operative temperatures in summer were very high, ranging from 30◦C to 37◦C, their results regarding ventilation and solar gain stood out once again, as they were similar to those obtained in the previous scenario.

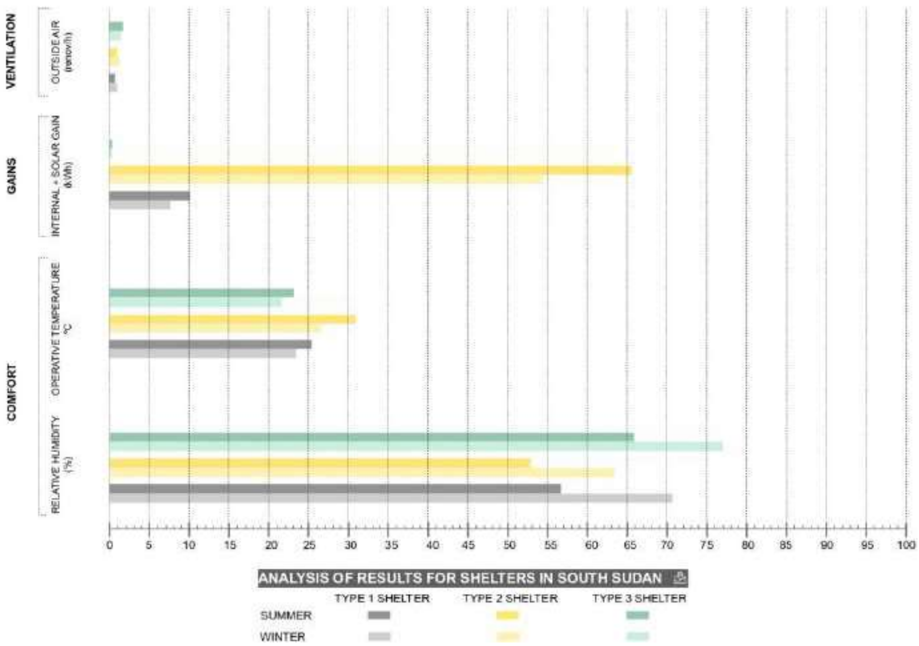


Figure 8. Results obtained from climate data of South Sudan.

Finally, figure 8 shows the results under the climate of South Sudan. It is noteworthy that in this case, the three shelters obtained higher values for relative humidity.

Operative temperatures were similar in the three cases, although the type 2 shelter obtained the higher values once again.

However, in this case, the type 3 shelter obtained outside ventilation values which were higher than those obtained by the other two shelters, ranging from 1-1.70 h^{-1}.

The situation regarding solar gain values remained the same: the type 2 shelter obtained high parameters, the type 1 shelter exhibited more constant values and the type 3 shelter showed negligible results.

In conclusion, the type 2 shelter obtained very high values regarding solar gain in every case, and its operative temperatures were the highest ones, especially in summer. Likewise, the type 3 shelter exhibited interesting values regarding comfort, but its solar gain was negligible. Meanwhile, the type 1 shelter showed the most constant and logical values in the three scenarios.

The results obtained were verified with Givoni's chart, which considers temperature, humidity and air in order to evaluate the thermal and comfort sensations. Regarding the climatic parameters of South Sudan in winter, the three shelters would fall within the comfort zone, according to this chart. The same is true for type 1 and type 3 shelters in summer, whereas the type 2 shelter would be outside that zone.

The results achieved with the climatic parameters of Jordan were similar to those mentioned above. In winter, the three shelters would be solved by internal gain heating. In summer, type 1 and type 2 shelters would be solved by natural and mechanical cooling, whereas the type 3 shelter would fall within the comfort zone.

Finally, the results obtained with the climatic parameters of Afghanistan showed the biggest differences. Type 2 and type 3 shelters would be solved in winter by internal gain heating, while the type 1 shelter would need passive solar heating. In summer, the type 1 shelter would be solved by natural and mechanical cooling, the type 2 shelter would need high thermal mass cooling with night ventilation and the type 3 shelter would fall within the comfort zone.

3.2. Qualitative results

A series of interviews conducted in parallel with this research were used in order to cross-check and merge the results obtained.

An overview of the most relevant aspects is shown in Figure 9:

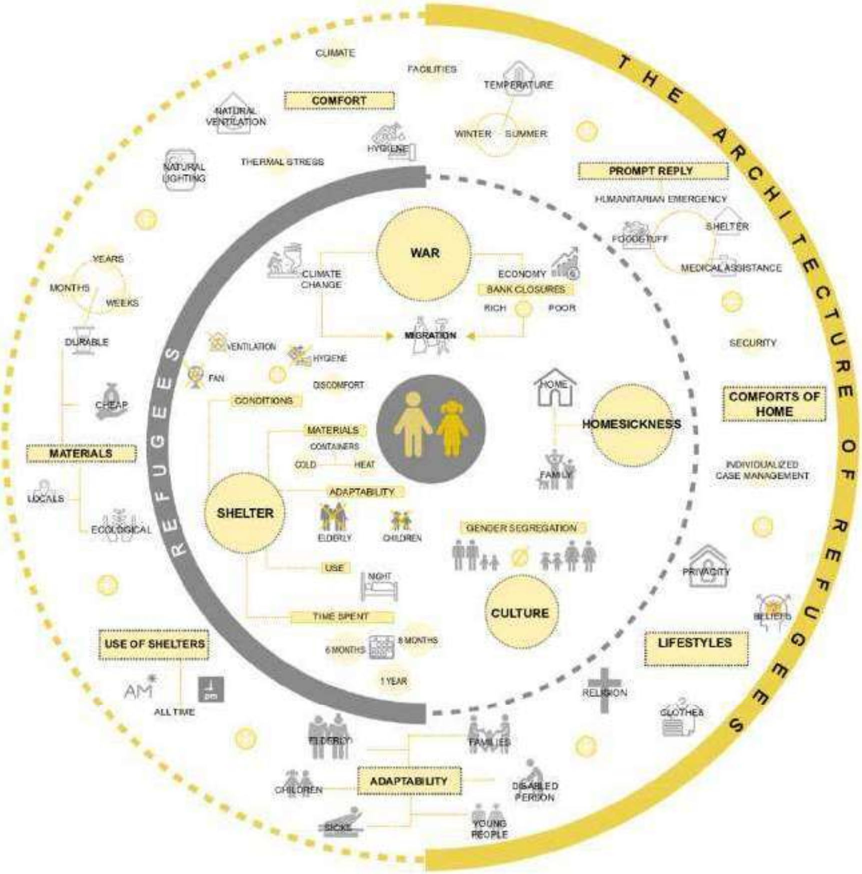


Figure 9. Overview of qualitative results.

Refugees stated that what they missed the most was their home, because they didn't feel as safe and comfortable as they did there, despite difficulties. Regarding their culture and the gender segregation inherent to their beliefs, they also noted that they needed a cultural privacy that they didn't have as refugees.

In relation to shelters provided, they claimed that the conditions regarding ventilation, hygiene or comfort were not appropriate. Likewise, shelters were not suitable for children or the elderly, and they could only stay indoors to sleep, due to the heat or cold (depending on the season) inside shelters.

Bearing all these aspects in mind, we drew a series of conclusions:

- Shelters must be prepared to be used at any time, which means that the materials used, in addition to meeting this factor, should be durable, cost-effective and locally available.
- They must meet comfort parameters, so they should be adapted to the climate, as well as being provided with natural ventilation and light, and a proper internal temperature in order to avoid any risk of thermal stress. All these factors have been corroborated by quantitative results.
- They must be suitable for all types of people, ages and families, taking their cultures, religions, habits and beliefs into account, thus providing an individualized case management.

4. Discussion and conclusions

Having analyzed all the results obtained, it was determined that the best-performing model in every climatic scenario was the type 1 shelter developed in Jordan.

It exhibited the most stable values, and all things considered, it provided the greatest comfort for its users, unlike the other two shelters.

Even though it is true that the type 3 shelter showed very constant values regarding its operative temperature (between 20°C and 30°C) in the three scenarios and its ventilation stood out above the other two shelters, its relative humidity exceeded 60% on several occasions.

Ventilation values for the type 2 shelter were very similar to those obtained by the type 1 shelter. In every summer scenario, it reached operative temperatures over 30°C, which was the main reason to rule out this option, in addition to its pretty high values regarding solar gain.

Several initial improvement factors could be added in order to achieve the best scenario or the best shelter model. In this case, we would choose the type 1 shelter and change certain features:

Firstly, as discussed in the qualitative results and proven in the quantitative results, ventilation is a limited factor. In every simulation, the values exhibited were quite low, making it difficult to live inside the shelter. Regarding the type 1 shelter, it obtained 0.70 h^{-1}.

In order to improve this aspect, solar gain should be taken into account from the beginning, because if openings were increased to achieve an improved ventilation, the impact of solar radiation would rise, thus increasing solar gain and temperature.

Therefore, we should find a middle ground regarding the dimensioning of openings, in order to achieve a proper ventilation without an excessive solar gain.

Secondly, given that the shelter has an insulating layer, this could be changed and adapted to each climatic scenario, thus improving the thermal inertia and making it possible to improve the shelter in the Jordan and Afghanistan scenarios, reaching similar temperature values to those obtained by the type 3 shelter.

Thirdly, we should consider ventilation control systems which can be controlled and handled by the user, thus developing adaptive strategies.

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