Sustainability of post-disaster and post-conflict sheltering in Africa: what matters?

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Abstract

Africa is the continent with the highest number of displaced people due to wars, humanitarian crises, resource scarcity, and extreme climate events. Post-disaster and post-conflict (PDPC) sheltering always sets out with the best intention of being a temporary solution but, in most cases, it turns into a (semi-)permanent habitat. Yet, sustainability criteria are seldom accounted for in PDPC sheltering even when some of the largest 'temporary' camps now host the third generation and house as many people as a medium sized city. The lack of consideration regarding sustainability mostly boils down to the view of sheltering as a product rather than a process, with a focus that, to date, has been either too technical (e.g., "tents-in-a-bag", "plug-and-play-houses") or too social (e.g., by investigating personal and social needs) without harmonising the two. This article aims to address this issue and advance the global debate on shelter sustainability by tapping into interdisciplinary expertise on both the African context and refugees' sheltering. A gender-balanced panel of experts identified key features of promising solutions through an iterative approach starting from existing available designs. Analytical Hierarchy Process (AHP) was then applied to establish the weight of technical and sustainability (across the three pillars of economy, environment, and society) indicators across the identified key features. Results show that solutions which adopt natural materials and local building techniques score the highest across the economic, environmental, social, and technical dimensions. Furthermore, the relative importance of these macro-categories differs greatly across genders, with female experts assigning a significantly stronger weighting to social indicators and male experts to environmental indicators. This research sheds new light on the sustainability of sheltering in Africa and paves the way for further work in the area.

Keywords: post-disaster; post-conflict; sheltering; Africa; refugees; sustainability; AHP; Delphi.

1. Context and background

Today's humanitarian crises have increased in frequency, impacting more people and for longer periods of time. By the end of 2017, the United Nations High Commissioner for Refugees (UNHCR) reported over 70 million persons of concern globally (UNHCR, 2017a), and 85% of the world's displaced people are hosted by developing countries (UNHCR, 2017b). Africa hosts more than 37 million persons of concern, of whom over 6 million are refugees (UNHCR, 2017c). All these people require sheltering, which is therefore a major global humanitarian issue. Post-disaster and post-conflict (PDPC) sheltering[1] always sets out with the best intention of being a temporary solution but, in most cases, it turns into a (semi-)permanent habitat (UNHCR, 2012). The Dadaab refugee camp in Kenya started hosting Somali refugees in 1991 and continues to grow (Figure 1) to the point that if it were a city it would be the fourth-largest of Kenya (Guardian, 2011). Unsurprisingly, after 28 years there are people who have children and grandchildren that were born in the Dadaab refugee complex[2] (UNHCR, 2018).

Figure 1 - Ifo, one of the four refugee camps in the Dadaab complex (Kenya) [left], and the City of London and central London [right]. The scale is the same and the spatial extension of Ifo exceeds that of the City of London – source Google Maps (2019)

While sustainability is at the heart of a global agenda on the development of cities (Haughton and Hunter, 2004; Huovila et al., 2019), it is seldom considered in refugee camps and PDPC sheltering as emphasised in a recent joint report by Ramboll & Save the Children (2017). The report unveiled the shortcomings of current shelter design, highlighting a lack of life-cycle thinking as a potential missing link between design and sustainability. Ramboll & Save the Children (2017) particularly highlighted a lack of appreciation of the environmental impacts of aid shelters as a clear knowledge gap and noted that the fact that harming the environment is often neglected despite the contribution to natural disasters, which in turn forcibly displaces even more people.

There remains, however, a tension between the need for stockpiled, instantly deployable shelters and the view of shelter as a process where local communities become implementing partners in the event of a crisis to drive long-term development

[1] Sheltering terminology is varied, diverse, and poorly agreed upon. Our choice for post-disaster post-conflict sheltering aims to be self-explanatory and to minimise confusion. For further discussion, the reader is referred to Barakat (2003) and Albadra et al. (2018).

[2] The Dadaab refugee complex consists of four camps: Dagahaley, Ifo, Ifo 2 and Hagadera.

by empowering the community. To this end, this article aims to build on existing research and advance the global debate on shelter sustainability by tapping into interdisciplinary expertise on both the African context and refugees' sheltering. The following section reviews existing literature, while the mixed method research design used is described in Section 3. Results are presented and discussed in Sections 4 and 5, while Section 6 concludes the article.

2. Literature Review

In a systematic literature review focused on the past and future of post-disaster reconstruction, Yi and Yang (2014) highlighted several aspects which are key to the scope of this article. Firstly, when mapping global hubs of research in the field they found that Africa is hardly represented. This adds to the finding that most of the research in the field is carried out by academics in developed countries, often neglecting the need for, and availability of, expertise in developing countries. They further highlight that future research should focus on sustainability and integrated development, which they have identified as an existing and significant gap (Yi and Yang, 2014). Within this sustainability ethos, the authors make a compelling case for considering sustainability as early as possible after the disaster occurs rather than "revisiting the issue after life returns to normal" (Yi and Yang, 2014, p.28). This aspect echoes the findings of Abrahams (2014) who undertook a case study of transitional shelter implementation in Haiti and concluded that neglecting environmental sustainability can exacerbate the impact of the disaster and hinder the long-term recovery. The author also identified barriers to environmental sustainability, which he grouped into prioritisations and perceptions within the disaster response sector, as well as structural and organisational barriers within the disaster response framework (Abrahams, 2014).

Existing academic literature on the sustainability of post-disaster sheltering solutions is scarce. In addition to the report by Ramboll & Save the Children (2017), which concluded that this aspect is often overlooked, Albadra et al. (2018) reviewed academic literature over the past four decades and found that only a few academic papers addressed sheltering sustainability and life-cycle environmental impacts. Within this body of literature, most articles focus on temporary housing and are based on case studies. Atmaca (2017) carried out a life cycle assessment (LCA) for container and prefabricated houses across a 15 and 25 year lifespan in Turkey, finding higher carbon and energy values for the container houses. In a study that also considered life cycle costs (Atmaca and Atmaca, 2016), the authors found that in addition to lower energy requirements, prefabricated houses also incurred 30% lower costs on average. Both studies concluded that the majority of the whole-life energy and carbon is linked to the operational phase, with materials and construction accounting for a mere 12-14%.

Conversely, Song et al. (2016), who carried out an LCA of light-framed temporary housing in a case study in Nanjing, China built with local technologies, found that the life cycle energy of post-disaster temporary housing is much higher than that of low-energy buildings, and that the construction contributes to 65% of the whole-life energy. To mitigate such high embodied energy, the authors suggested using recycled materials as well as lighter structures and light cladding.

Amin Hosseini et al. (2016) conducted a case study of temporary housing units in Bam, Iran and, rather than quantifying impacts, they propose a new multi-criteria decision-making method to assess the sustainability of post-disaster temporary housing units. Their sustainability analysis is based on the three sustainability pillars and considers economic, social, and environmental requirements. Economic indicators are construction and maintenance costs; social indicators are construction time, risk resistance against natural or man-made disasters, and comfort; and environmental indicators are embodied energy and carbon, waste generation, and water consumption (Amin Hosseini et al., 2016). This framework is then applied to four different solutions to identify the one that offers the best performance. One issue with their results is that values for embodied energy and carbon are entirely taken from the ICE database (Hammond and Jones, 2011), which is strictly UK specific and therefore unlikely to represent the Iranian context. The use of inapplicable numbers might well affect the validity of the results produced although the framework could still be used if supported by appropriate data.

Another framework, with the different aim of assessing the resilience embedded in reconstruction projects of post-disaster housing, was developed by Ahmed and Charlesworth (2015). Their framework was intended to be used as a tool in the field and is based on three stages: pre-assessment, assessment, and consolidation. Their take on sustainability is that more resilient housing, designed with future risks in mind, can increase its durability and thus prove more sustainable. The authors tested their tool in the Cook Islands and Sri Lanka, concluding that it proved useful to NGOs to evaluate the disaster resilience of previously built housing projects.

Arslan and Cosgun (2008) adopted a qualitative approach to investigate the reuse and recycle potential of temporary houses after occupancy, from a case study in Duzce, Turkey. They observed production, occupancy, and dismantling phases concluding that better pre-disaster design and organisation is necessary to maximise the recycling and reuse potential of housing units once they have been vacated. The authors also identified the necessity of integrated planning and distribution between all actors involved (local and national governments, NGOs, and the affected communities). In another case study in the same location in Turkey, Arslan (2007) optimised the design of a temporary housing unit to maximise the reuse and recycle potential in the transition from dismantling the unit to the reconstruction of a permanent house.

Design was also the key focus of Tucker et al. (2014) who used a case study in Sri Lanka to illustrate a structured approach to sustainable design of post-disaster housing. This was used to generate a housing design that meets the desired environmental criteria. One of the limitations that the authors identify, in line with what Yi and Yang (2014) also highlighted in their review, is the lack of involvement of relevant stakeholders (e.g. inhabitants) or expert groups in developing countries. Nonetheless, their approach of applying lessons from traditional housing to the construction of post-disaster housing shows that more sustainable solutions can be achieved “because the materials and construction methods are more rooted in the cultural and climatic contexts” (Tucker et al., 2014, p.177).

In a recent study, Fosas et al. (2018) focused on improved refugee housing through cyclic design applied to the Azraq camp in Jordan. Their work is solely focused on the operational phase (i.e. the occupancy stage) and the authors propose the thermal monitoring of existing shelters to develop and validate baseline simulation models, which can then be used for improvement and optimisation cycles before mass-construction (Fosas et al., 2018). Their analysis of the Azraq camp revealed that existing shelters overheat significantly, causing thermal distress and increased morbidity. The cyclic design approach they proposed resulted in the incorporation of simple passive design strategies which yielded substantial performance improvements in terms of thermal comfort.

Escamilla and Habert (2015) offer a more holistic approach to sustainability evaluation through their assessment of the economic and environmental performance—through life cycle costing (LCC) and LCA, respectively—of 20 shelter designs across 11 different global locations. They concluded that both global and local materials can be used sustainably in sheltering, and that shelters with high cost and/or environmental impact are not associated with a better technical performance. In particular, local materials provide better environmental performance and lower costs while globally sourced materials show higher costs and better technical performance (Escamilla and Habert, 2015). Later work, partly by the same authors (Celentano et al., 2019), identified the speed of shelter delivery as a crucial element to respond to crises efficiently and avoid spontaneous unsafe or unlawful informal re-settlements. They found a significant correlation between material procurement and speed, with construction time strongly influenced by the complexity of roof design (Celentano et al., 2019). They also proposed a multiscale approach for material selection to drive efficient reconstruction.

Technical aspects are a fundamental consideration as they help pinpoint solutions that are technically sound and economically viable. However, some of the studies reviewed showed that focusing solely on the technicalities of shelter design risks sheltering being viewed as a product rather than as a key element of a process that accepts incremental additions and amendments. According to the International Organisation for Migration (IOM, 2012), this is a vital role of shelters. Technical assessments also exclude social considerations, and solutions designed solely with a technical focus in mind can fall short of meeting users' needs and respecting diverse and local cultures. Social and cultural inadequacy is indeed one of the shortcomings in PDPC housing identified by Félix et al. (2013). Significant improvements in cultural aspects and social sustainability have also been identified as critical elements to improve global humanitarian response by Alshawawreh et al. (2017), during site visits to the Syrian camps in Jordan and interviews with their residents. Geographical foci are important not just to account for the diversity of cultures that must be respected, but also for an effective design that reflects the diversity of the global climate. This is evident from the Köppen-Geiger (Beck et al., 2018; Peel et al., 2007) climate classification map (Figure 2).

Africa has several clearly distinguished climate zones and, realistically, each one would have solutions that work better than they do in different climates. One-size-fits-all solutions are therefore unlikely to ever work in PDPC sheltering, much as they fail to work for regular buildings (Oliver, 2007), as they ignore the diversity that exists both with people and the environment.

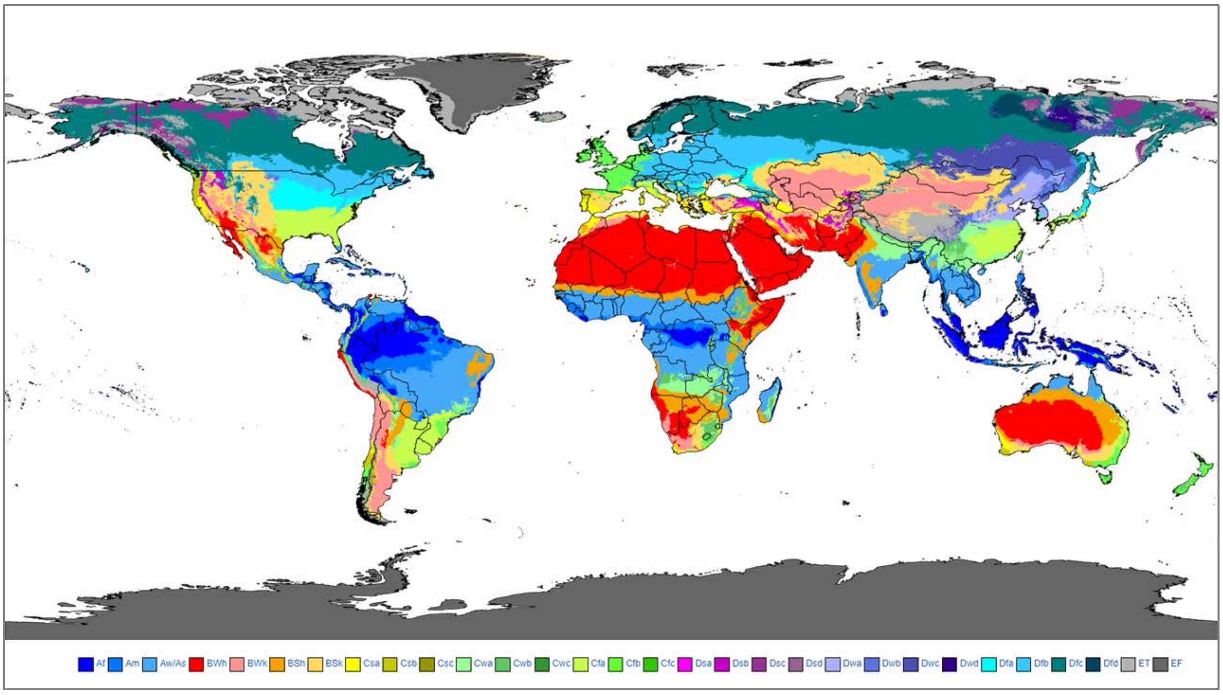

Figure 2 – Global Köppen-Geiger climate classification map (Beck et al., 2018) - CC BY 4.0

The literature reviewed in this section has highlighted several important aspects, which this article intends to build on. Firstly, Africa is severely underrepresented in the existing literature at different levels: as the focus of existing studies, in terms of academic authors, and in providing local expert knowledge and stakeholders' involvement. These are all key elements to achieve long-term development, sustainability, and community empowerment. Furthermore, a substantial share of the existing literature is based on case studies. This proves the need for a contextualised approach with local foci, due to the sheer difference that exists in PDPC situations around the world. This view is further supported by technical analyses and life cycle assessments carried out for different shelter solutions around the world: no single optimal solution exists from a technical, environmental, and economic viewpoint. Additionally, short-termism does not pay off and the benefits are only maximised if sustainability considerations come as early as possible following a disaster or conflict.

An opportunity also emerged to learn from traditional housing techniques, including materials and construction methods, which could result in solutions better suited to meet the needs of their intended users. Additionally, the literature reviewed showed that, in order to be holistically addressed, sustainability requires the consideration of at least the following four intertwined dimensions:

- technical performance – to ensure solutions that are fit for purpose
- economic viability – to ensure solutions can be realistically procured by NGOs and deployed in the field
- low environmental impacts - to reduce the harm to the planet and to avoid high carbon emissions due to materials, transportation and operation that in turn further contribute to climate change and natural disasters, and
- social suitability – to ensure the solutions benefit the intended users and their communities and act to drive long-term empowerment and development.

All these considerations have formed the basis for this research, and helped to shape the methodology adopted, which is discussed in the next section.

3. Methodology

The interdisciplinarity of this research, as well as the complexity of the topic it deals with, guided us towards a mixed methods research design and the overarching framework is shown in Figure 3.

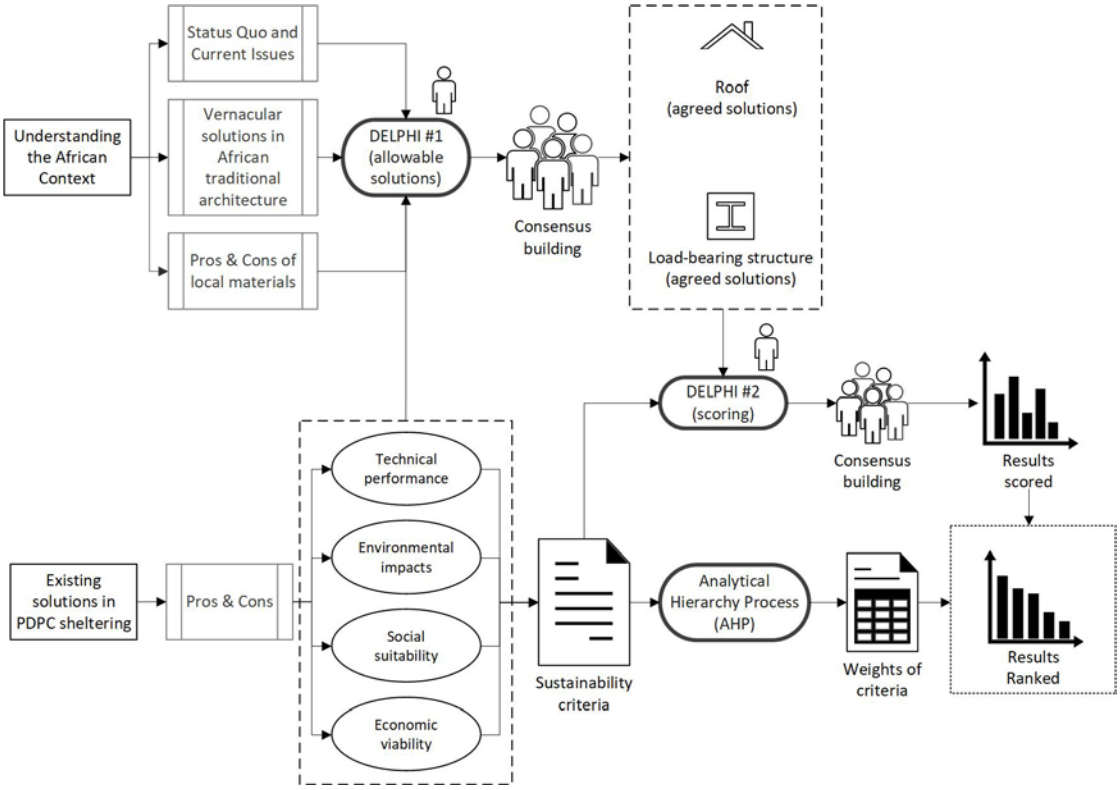

Figure 3 - Mixed methods research framework designed for, and utilised in, the current research

Preliminary work was carried out in parallel at both the University of Cape Town, Africa, and Edinburgh Napier University, UK. Team members in Africa focused on understanding the status quo in the country, including numbers of displaced people, shares of people displaced by conflict and by disasters, number and population of informal settlements, and country specific analyses for Uganda, Kenya, Ethiopia, Sudan, DRC, Nigeria, and South Africa. The team also worked on retrieving, reviewing and understanding information related to traditional African architecture (e.g. Denyer, 1978), as well as traditional construction techniques and local materials (e.g. Van Lengen, 2008). Concomitantly, the team in the UK reviewed and analysed the state of the art on post-disaster post-conflict sheltering. The analysis focused on both existing solutions (PDPC shelters that have been used in the field) and novel designs (PDPC shelters that have been engineered and prototyped but never deployed in a disaster/conflict context). Both clusters have been assessed against the four key dimensions which emerged from the literature review: environmental impacts, social suitability, economic viability, and technical performance.

The analysis of these four dimensions allowed a comprehensive list of sustainability criteria to be derived. The factors identified for each sustainability dimension are shown in Table 1.

Table 1 - Factors considered across the four sustainability dimensions

Social	Social Status
	Involvement of local people
	Familiarity to intended users
Environmental	Local availability of materials required
	Healthy (does not harm, e.g. toxic substances)
	Low environmental impacts (e.g. carbon emissions)
Economic	Low construction costs
	Long potential lifespan
	Low life cycle costs
Technical	Easy to maintain
	Safe (e.g. low fire risk, sound structure)
	High construction speed

Both teams prepared reports of their work that constituted the starting point for the following phases of the research, namely the Delphi and the Analytical Hierarchy Process (AHP) methods. The Delphi has been used twice: to reach consensus on a manageable number of agreed solutions for both the load bearing structure and the roof of PDPC sheltering (Delphi #1), and to reach consensus on the scoring of the identified solutions based on the sustainability criteria identified in the preliminary phase (Delphi #2). The AHP has instead been used to assign weights to the sustainability criteria (through the individual comparative weighting of the factors presented in Table 1), and combined them with the scored results in order to rank the results according to the individual weights of each criterion. Both methods are described in detail in the following sub-sections.

3.1 The Delphi method

The Delphi method (or technique) was first presented by Norman Dalkey and Olaf Helmer in the 1950s (Franklin and Hart, 2007) and it has since been widely employed in several aspects of management, applied, medical, engineering, environmental, and social sciences (Ameyaw et al., 2016; Harland et al., 1999; Jorm, 2015; MacCarthy and Atthirawong, 2003; Strand et al., 2017). A Delphi is often used either as a forecasting technique or as a tool “to investigate and understand the factors that influence or may influence decision-making on a specific issue, topic or problem area” (MacCarthy and Atthirawong, 2003, p.796). In practice, the Delphi structures a plural communication so that individuals can effectively deal with complex problems (Linstone and Turoff, 1975) through a systematic and iterative process that aims to develop a consensus by attempting to use the combined knowledge of a panel of experts (Wisniewski, 2009). However, the Delphi should not be confused with other techniques using multi-expert opinions (e.g. workshops) since it avoids group interactions of individuals that might result in induced response, and requires anonymity to prevent biases (MacCarthy and Atthirawong, 2003). Therefore, “the psychological factors affecting panel discussions such as compromising, the ‘bandwagon’ effect, or displaying an unwillingness to reverse or modify a previously stated opinion in the face of reasonable counter arguments, can be minimized" (McDermott and Stock, 1980, p.3). Overall, the Delphi is characterised by four specific features (Benson et al., 1982; Tavana et al., 1996): (1) anonymity among the panel of experts; (2) obtaining a statistical group response from structured questioning; (3) iteration; and (4) controlled feedback. They have all been adhered to when implementing the Delphi for this research.

The panel selection is at least as vital as the questions asked. According to Clayton (1997), an accurate choice of the panel members is essential for the reliability of the data collected throughout the process. However, what does "to be expert" mean? As expressed by Martino (1993), panellists should be expert in knowing more than most people about the topic being considered. Therefore, a panel member should be selected with regard to the topic under investigation and expertise in other areas is irrelevant. In order to achieve a comprehensive perspective of the topics considered, the panel members should also come from several fields. Sampling them all from the same professional and cultural background would be the first step to invalidate the study. Thus, these guidelines were followed in convening the panel of experts. A further issue in selecting panel members is in their number. A recent study (Toppinen et al., 2017) reports that Delphi panellists can range from few to 50, and within the existing literature only one study suggested a rule for the number of experts to be involved. McDermott and Stock (1980) suggest that consensus decisions achieved by Delphi panels with five or more experts are superior to individual decision making. Therefore, we have attempted to avoid this lower bound reference value and managed to recruit a total of nine experts for this research. Details that can be disclosed about the panel are given in Table 2.

Table 2 - Background details on the expert panel

Professional Background	**Geographical location**	**Gender**
Humanitarian engineering	Africa (3)	F (5)
NGO (Refugee camps)	Middle East (2)	M (4)
Architectures of emergencies	Europe (4)	
Bio-architecture		
Biomimicry and policy-making		
Construction management		
Project management		
Structural engineering		
Humanitarian logistics		

3.2 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a structured technique for handling complex decision-making problems which was developed by Thomas Saaty (1987; 1988) and has also been applied in conflict- and disaster-related research (e.g. Saaty, 1990; Tuğba Turğut et al., 2011). Both quantitative and qualitative factors are combined by using the AHP in the decision-making process. AHP is a flexible and adaptable tool and it has therefore found several applications in the field of engineering and the built environment. For instance, it has been used to select the location of tsunami shelter (Choi et al., 2012) as well as environmentally friendly design alternatives (Ng, 2016), or to identify suitable construction methods for bridges (Pan, 2008) and building components (Moghayedi and Windapo, 2018). The AHP can be divided into the following steps:

1. Structure the decision hierarchy, considering the goal of the study and determine the criteria and sub-criteria
2. Establish a set of all judgments in the comparison matrix in which the set of elements is compared to itself
3. Determine the relative importance of factors by calculating the corresponding eigenvectors to the maximum eigenvalues of comparison
4. Verify the consistency of judgments across the Consistency Index (CI) and the Consistency Ratio (CR)

In our specific case, this meant creating a set including the dimensions and their factors presented in Table 1, which was compared to itself by using the fundamental scale of pair-wise comparison shown in Table 3. The criteria on the same level of the hierarchy are compared to establish the relative importance compared to the criterion of the higher level. This process allows values that weigh criteria to be obtained and to define a ranking of the alternatives. For instance, within the social dimension, one sample comparison was 'Kindly indicate the relative importance of familiarity to people to social status'. This was implemented in Excel to capture the quantitative nature of the method and a sample screenshot is given in Section 2 of the supplementary material.

Table 3 - Scale for pair-wise comparisons in AHP

Definition	Relative importance
Equal importance	1
Moderate importance	3
Strong importance	5
Demonstrated importance	7
Extreme importance	9
Intermediate values	2, 4, 6, 8

The Consistency Index (CI) is defined as:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad \text{(Eq. 1)}$$

where λ_{max} is the eigenvalue corresponding to the matrix of pair-wise comparisons and n is the number of elements being compared. The Consistency Ratio (CR) is calculated using the following equation:

$$CR = \frac{CI}{RCI} \quad \text{(Eq. 2)}$$

where RCI is a random consistency index related to the number of criteria (n) considered, with values given in Table 4.

Table 4 - RCI values –adapted from Saaty (1987)

Number of criteria (n)	RCI
1,2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

The measurement of consistency reflects whether an individual understands and captures the interactions among different factors of the problem, or if their decision is more a matter of randomly hitting a target. However, perfect consistency is hard to achieve in real life problem-solving. Saaty (1996) stated that inconsistency must be precisely one order of magnitude less important than consistency, or simply 10% of the total concern with consistent measurement. If it were larger it would disrupt consistent measurement and if it were smaller it would make an insignificant contribution to a change in measurement. This threshold has been applied in the AHP employed in this research.

4. Results (Delphi)

4.1 First application: determining allowable solutions

The first round of the Delphi saw the panel presented with the question of identifying allowable solutions for PDPC sheltering based on their diverse and multidisciplinary expertise, and in light of the evidence from the preliminary work carried out in Africa and the UK. Given the evidence from existing literature on the criticality of the roof, the experts were asked to treat the load bearing structure and the roof separately and identify allowable solutions for both They were also asked to bear in mind evidence presented related to the African contexts as well as positive and negative aspects of existing solutions and novel designs in PDPC sheltering. The panel was tasked with identifying a "manageable" number of allowable solutions where the exact number was not prescribed *a priori* but rather left to the consensus building process of the Delphi. In total, five rounds of the Delphi were required in this first application: two to reach consensus on load-bearing structures and three on the roof.

To rate the different elements in the Delphi, a three-point Likert scale was used (Jacoby and Matell, 1971) since our intention was not to achieve convergence towards a single solution, but rather to understand whether there was enough support by the experts to either keep or discard each solution in turn. It was not prescribed that each roof solution be applicable to every load-bearing solution but that at least one load-bearing solution could fit each identified roof solution. Regarding the latter, the number of allowable solutions exceeded the "manageable" number as intended by the research team. However, one of the strengths of the Delphi is to allow the panel to defend their views and maintain strong divergence in their opinions, indicating polarity among the experts into two (or more) schools of thought (McDermott and Stock, 1980). This phenomenon occurred in this research and therefore the Delphi was ended when no further agreement could be reached on reducing the number of allowable solutions for the roof. Results of what the panel decided are shown in Table 5.

*Table 5 - Allowable solutions for both the load bearing structure and the roof that emerged from the first application of the Delphi in this research - *Natural frame was intended as a frame made of natural materials (e.g. timber, bamboo)*

Allowable Solutions (load-bearing structure)	**Allowable Solutions (roof)**
Prefabricated frame structure	Flat - precast concrete and clay pot frame with mud plaster
Formwork with local infill	Flat - natural frame* and clay (on closely packed timber)
Sundried bricks	Flat - natural frame and corrugated sheeting
Sandbags	Pitched - frameless with sandbags
	Pitched - natural frame and corrugated fiberglass/resin
	Pitched - natural frame - thatch/grass
	Pitched - natural frame - tiles
	Pitched - natural frame - metal
	Pitched - natural frame - plastic
	Pitched - natural frame - canvas/hemp

4.2 Second application: scoring solutions against sustainability criteria

In the second application of the Delphi method in this research, the experts were presented with a questionnaire developed from the sustainability criteria that emerged from the preliminary work (Table 1). They were asked to rate each of the allowable solutions (for both the load bearing structure and the roof) against these criteria on a three-point Likert scale. The overall criteria had been clustered along the four main dimensions previously described: social suitability, economic viability, technical performance, and environmental impacts. The full questionnaire presented to the panel, and that was operationally implemented in Survey Monkey, is given as supplementary material. In the first round the experts were asked to provide individual ratings. These were collected, analysed, and combined by the research team and in the second round the panel were shown the combined results with the overall scores. At this stage, they were asked whether they agreed on the resulting score, which they did and thus the Delphi ended after two rounds. Given the 12 questions and the 14 solutions (10 for the roof and four for the load-bearing structures), the nine experts answered 168 questions each, totalling 1,512 valid answers. Clustered results for the load-bearing structure and the roof are shown in Figure 4 and Figure 5, respectively. Due to how the Likert scale was presented to the experts and implemented in the Delphi, lower numbers indicate better performance.

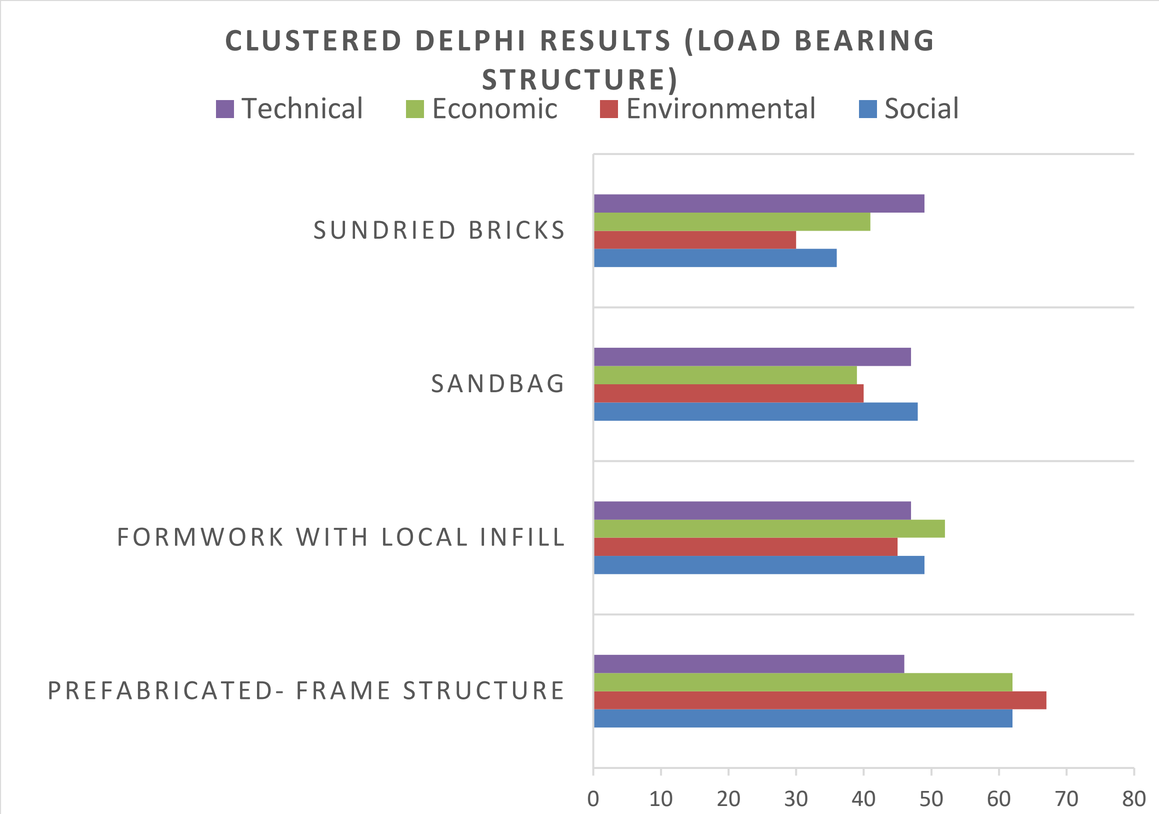

Figure 4 - Clustered results for the allowed solutions for the load-bearing structure from the second application of the Delphi. The scale on the x-axis refers to the summation of the results from the three-point Likert scale used by the experts. Due to how the Likert scale was presented to the experts and implemented in the Delphi, lower numbers indicate better performance

Figure 4 and Figure 5 show how different solutions (for both the load bearing structure and the roof) may have very good scores in one of the clusters and very poor scores in another, therefore leaving the decision maker unsure on what clusters should be prioritised. To address this gap, we have used the AHP to assign weights to different clusters and the results are shown in the next section. It should be noted however that the results presented so far (i.e. without further weightings applied) can also be extremely useful to expert decision-makers who already know well what the preponderant criteria in their specific context are and would therefore benefit from "raw" results which have not been further processed.

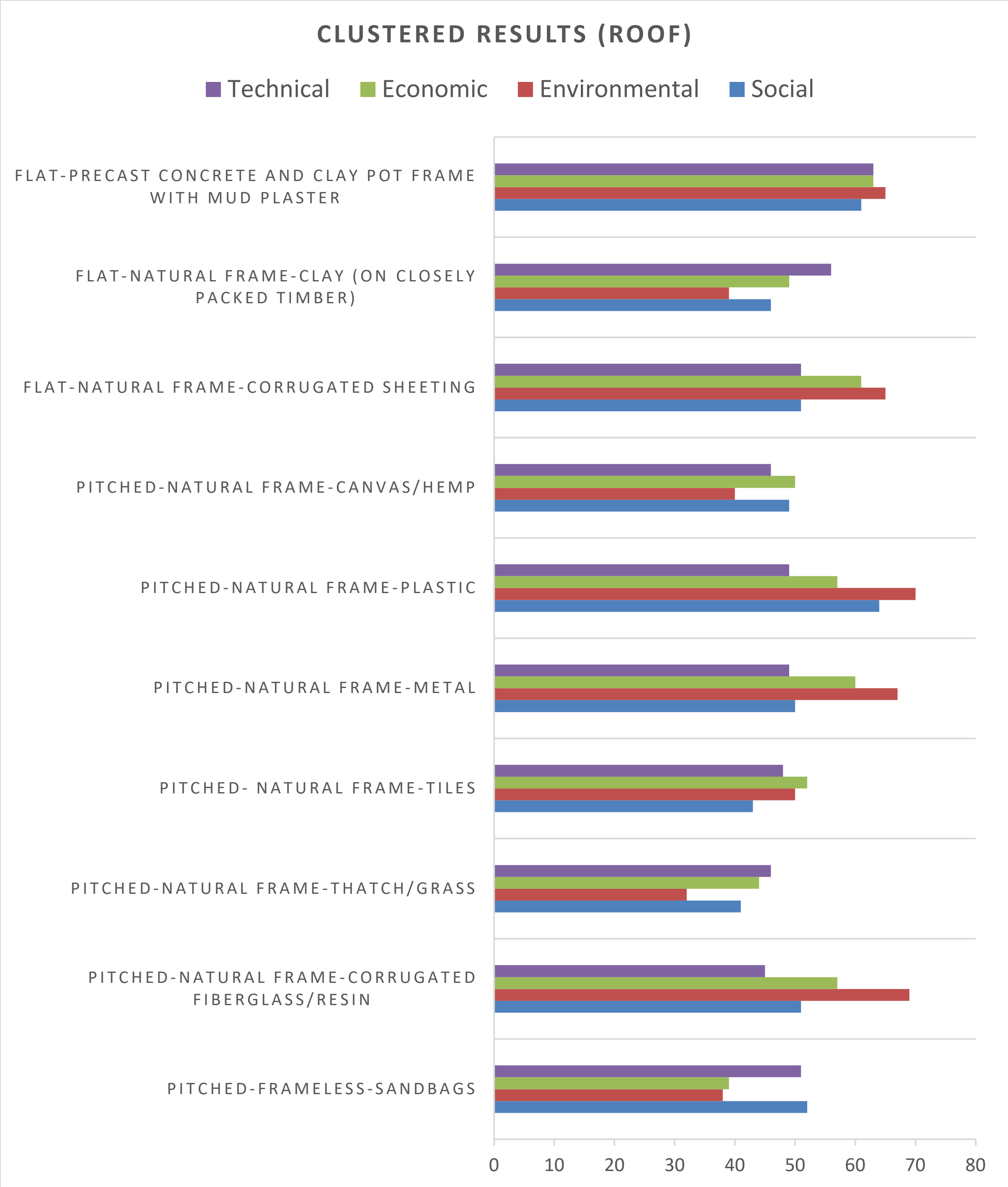

Figure 5 - Clustered results for the allowed solutions for the roof from the second application of the Delphi.. The scale on the x-axis refers to the summation of the results from the three-point Likert scale used by the experts. Due to how the Likert scale was presented to the experts and implemented in the Delphi, lower numbers indicate better performance

5. Results (AHP)

AHP was employed in this research to determine the relative importance of the four sustainability dimensions examined. Each expert produced their own scores which were then averaged across all members of the panel.

5.1 The relative importance of sustainability dimensions

Figure 6 shows the results from the AHP. On the left-hand side of the figure, results for the whole panel are shown. It can be noted that social suitability is the most important dimension, making up for 39% of the total share. It is followed by environmental considerations (29%), with technical performance and economic viability deemed as the least important dimensions with relative shares of 18% and 14%, respectively.

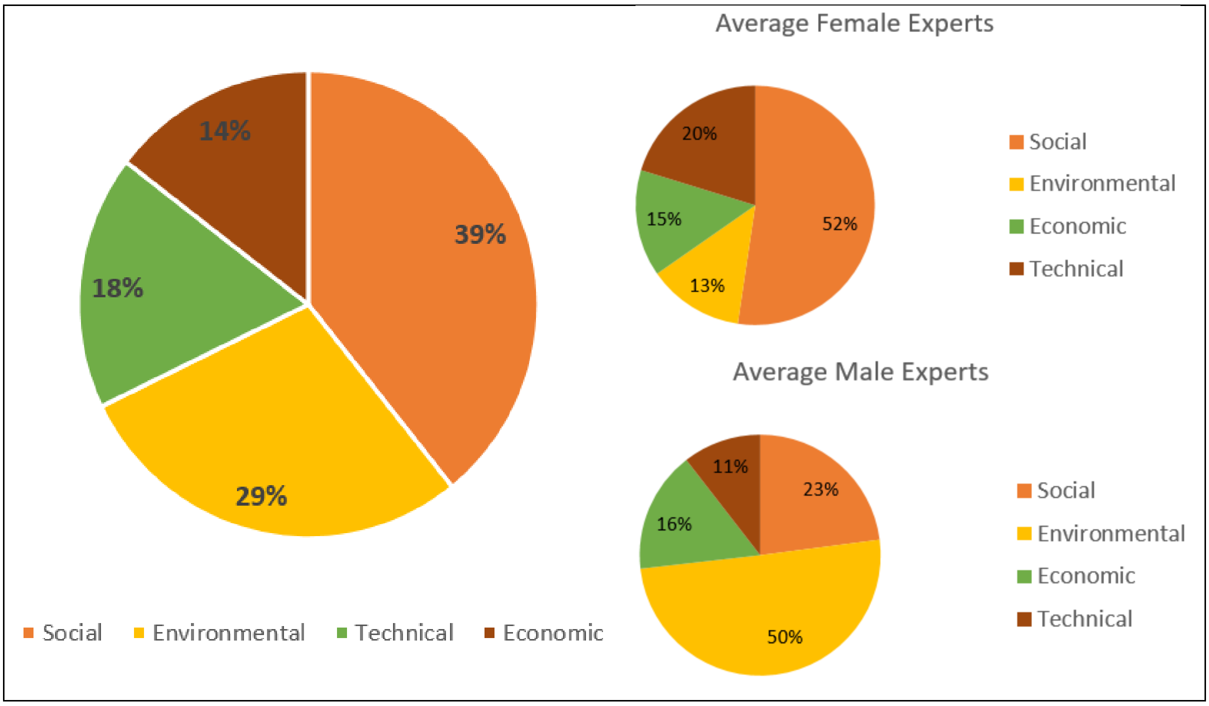

Figure 6 - AHP results for the four dimensions assessed (left), and the same results clustered according to a gender analysis for female (upper right) and male (lower right) experts

An additional, interesting finding that emerged from analysing the AHP results is the staggering difference in sustainability considerations when results are clustered according to the gender of our experts. Female experts felt strongly that social suitability was by far the most important dimension, making up for more than half of the total share. This is followed by technical performance that scored somewhat higher (20%) than economic viability (15%). Environmental impacts are considered as the least important dimension in PDPC sheltering by female experts, making up for just 13% of the total. This is wholly reversed when the analysis moves to male experts. For them, it is the environmental dimension which deserves the greatest attention (50%), followed by the social one (23%). Economic (16%) and technical considerations follow, but the technical performance, which was the second most important dimension for female experts, is surprisingly barely considered by the male experts, totalling just 11%. Such significant polarisation of results was not observed when the results were analysed against other commonalities related to the experts, for instance their geographical location. Explaining why results were so significantly different between male and female experts goes beyond the scope of this research, but our findings suggest that gender might well play a fundamental role in sustainability considerations and how different elements are prioritised. As such, gender perspectives and priorities in PDPC situations certainly represent an interesting and important area for further research.

5.2 Ranked results

The ultimate scope of having AHP weights was to use them to determine single overall scores for the allowable solutions identified for both the load-bearing structure and the roof. These are shown in Figure 7. As explained in the methodology section, a lower score indicates better performance due to how the Likert scale was presented to the experts.

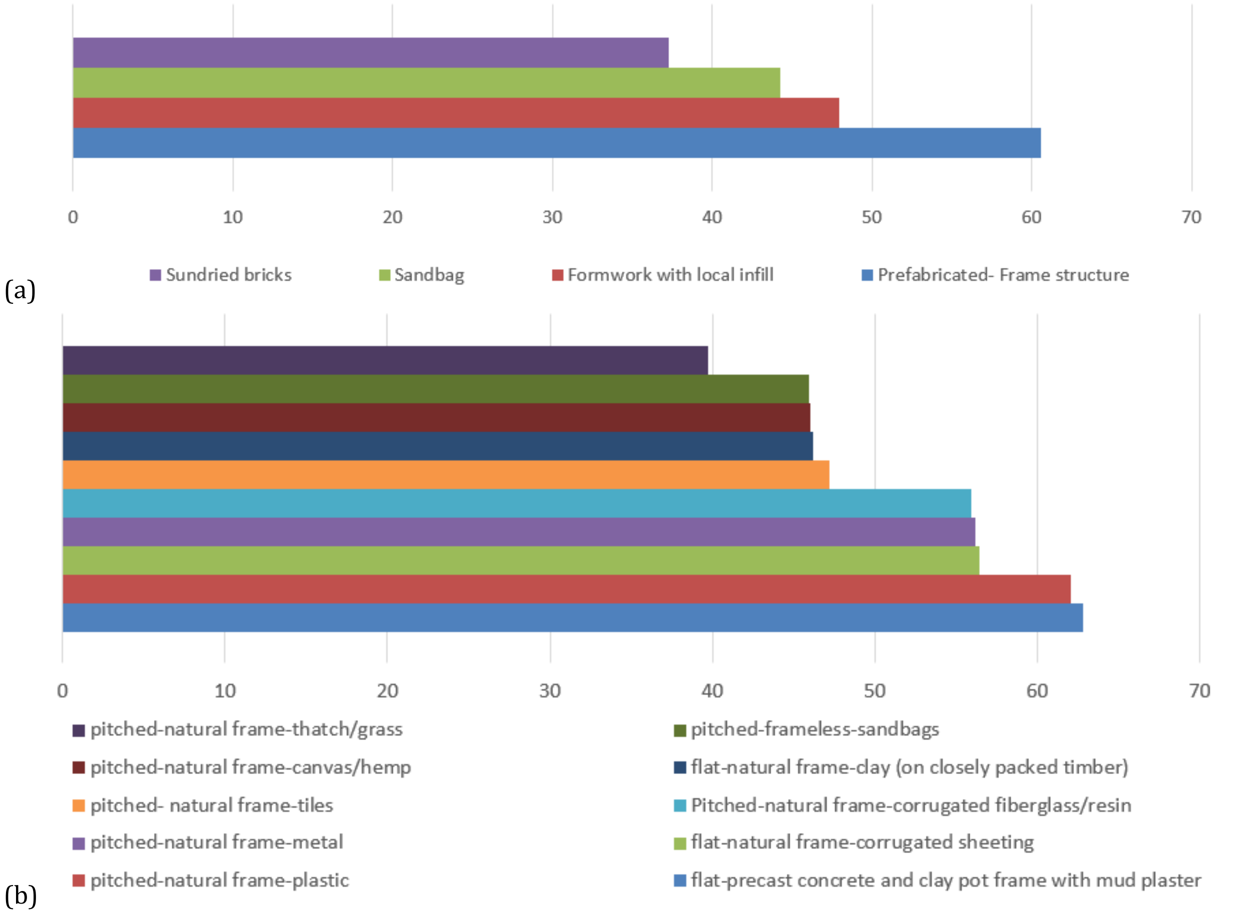

Figure 7 - Weighted results for the allowable solutions identified for both the structure (a) and the roof (b). Lower values indicate better performance.

Given the predominance of social suitability from the overall AHP results (Figure 6), which included sub-criteria such as local involvement and familiarity to people, it is unsurprising that the solutions with better performance are those that align greatly with those two sub-criteria. For instance, sundried bricks (Figure 7a) are the best-performing option for the load bearing structure because this solutions strongly relies on the local involvement of affected communities and, in the African context, it is also a technique likely to be known to many. Similarly, when it comes to the roof (Figure 7b), a pitched roof made of a natural frame covered by thatch or grass was the one with the best score. However, the weights obtained from the AHP have neared significantly different solutions which were further apart previously (Figure 5). For instance, in the case of the roof, apart from the clear winner mentioned above and the clear losers (concrete frame and natural frame with plastic sheeting), all other solutions are within 10 points of one another. This suggests that the preferred solution can differ depending on the context, and that there are more nuances to be considered rather than aiming to find an overall best performer for Africa.

6. Conclusions

Natural disasters and humanitarian crises have increased in frequency, impacting more people and for longer. The United Nations High Commissioner for Refugees classifies those people as forcibly displaced, and Africa alone hosts about half of the global total. Post-disaster and post-conflict (PDPC) sheltering is therefore a global humanitarian concern, which substantially impacts millions of lives. PDPC is often framed in terms of urgency and emergency and this has resulted in sustainability considerations seldom being accounted for, despite the fact that many refugee camps are as big as medium-sized cities. This article therefore intended to shed light on the sustainability of PDPC sheltering by adopting a mixed method research approach to tap into expertise on both the African context as well as refugees' sheltering.

Through multiple rounds of Delphi and the use of AHP, the aim was twofold. First, we sought to identify allowable solutions that would work for PDPC in Africa and assess their performance across four main sustainability dimensions: social suitability, environmental impacts, technical performance, and economic viability. Second, we wanted to establish the relative weights that those dimensions have when evaluated comparatively. It emerged that social and environmental considerations are the most important sustainability dimensions for PDPC sheltering in Africa, according to our diverse panel of experts. We also found that results vary greatly if they are clustered and analysed according to the expert's gender. Female experts ranked social sustainability the highest and environmental sustainability the lowest. Male experts conversely ranked environmental sustainability the highest, but social sustainability was second (and not last) in importance. Our results suggest that solutions which are familiar to people and involve them as much as possible, and that are made of natural and local materials would be preferred from an overall sustainability perspective. However, for many of the solutions analysed results are relatively close, suggesting that several solutions might work best depending on the context and on which specific criterion is to be prioritised in a given context.

This study has a number of limitations, which can also point towards future work. The expert panel, while meeting existing guidelines for Delphi studies and AHP, was limited to only nine people. Broader groups of experts could produce different results and therefore our findings could be further evaluated when the number of experts involved increases. This represents an interesting area for further research, either as a broader Delphi, or through other means such as surveys, questionnaires and interviews to gather the views of a larger number of people and even more stakeholders. Another limitation consisted of using existing solutions and novel designs for post-disaster and post-conflict sheltering to identify sustainability factors and elicit the experts' opinion. This could have limited their freedom somewhat in identifying alternative solutions which have not yet been used nor even designed. Using the findings from our work as the inputs to a design exercise with no boundaries could therefore be interesting for future work. Similarly, reviewing existing solutions in light of the comparative weights that we have identified could add a quantitative, more holistic metric to the sustainability evaluations of PDPC solutions for Africa. In this article, we focused on the generic definition of post-disaster and post-conflict sheltering, to capture the sudden need for large numbers of people to relocate, thus triggering an unplanned increase in sheltering demand. However, the post-disaster and post-conflict contexts are very different and while technical solutions that work for one might also work for the other, the operating environment (e.g. actors involved, in-country support, etc.) is utterly different. This represents a further limitation of our work and future research could have a deeper focus to represent the peculiarities of the two contexts. Lastly, the gender polarisation in the results that we observed is an interesting trait which deserves to be further investigated with broader numbers to support conclusive claims.

It is hoped that by enriching and broadening our understanding of sustainability considerations in post-disaster and post-conflict sheltering we will be able to move away from an urgency-driven operating mode and develop effective solutions that are tailored to the context of use and sustainable in both the short- and long-terms.

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