Healthy Housing
for the Displaced

Healthy Housing for the Displaced

UK Shelter Forum 25

25th Oct 2019

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Healthy Housing for the Displaced

Drivers for this research

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Why are we doing this?

Millions displaced

>40°C in summer
<0°C in winter

Who is funding this?

DFID Department for International Development

EPSRC

GCRF Global Challenges Research Fund

Healthy Housing for the Displaced

The Team

Primary Investigator Prof. David Coley

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WP1
Field Measurements


Dr Jason Hart


Dr Natalia Paszkiewicz


Dr Dima Albadra


Dr Richard Ball

WP2
Modelling Solutions


Dr Sukumar Natarajan


Dr Juliana Holley


Dr Daniel Fosas


Dr Maria Manuela

WP3
Physical Solutions


Dr John Orr


Dr Francis Moran

Industrial Steering Committee


Dr Steve Lo

WP4
Science of Shelter Design


Dr Kemi Adeyeye


Dr Steve Lo


Dr Dima Albadra


Noorullah Kuchai

WP5
Material Supply


Prof David Coley


Dr Alex Copping


Noorullah Kuchai


Dr Laura Hattam

Healthy Housing for the Displaced

The Disciplines

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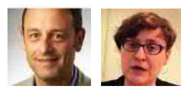
Building Physics

Architectural Technology & Design

Environmental Design

Sustainable Materials

Anthropology



Civil Engineering

Practitioners

Project Management

Mathematical Innovation

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WP1 Surveys

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Complete largest ever uniform linked thermal, air quality, and social study in five camps. Collect the views of camp occupants and aid agencies on possible shelter improvements and limitations.

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WP2: Computer Modelling Solutions

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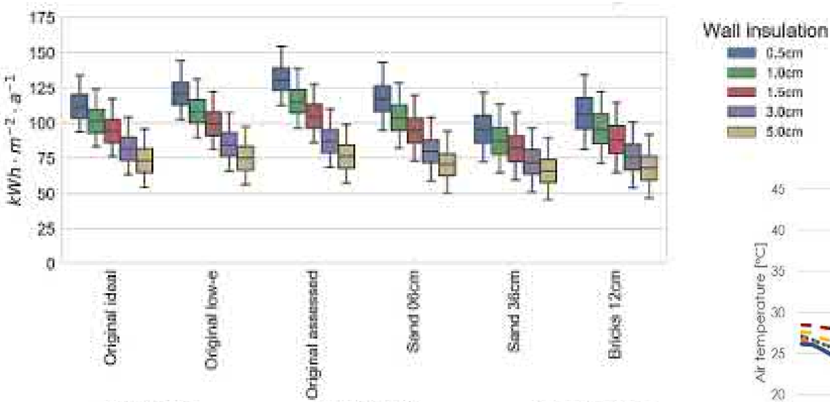
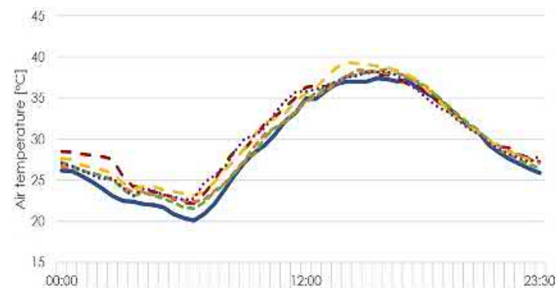
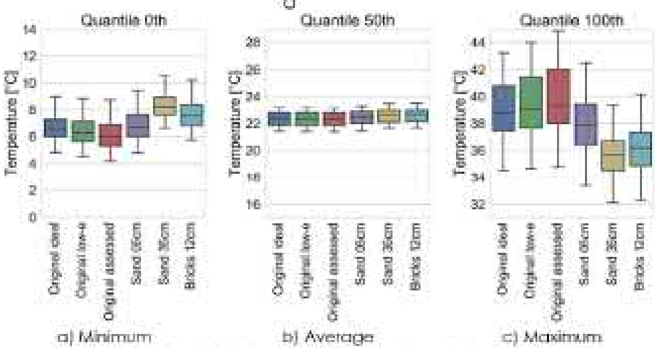
Develop and enhance the science behind thermal modelling of shelters. Create an optimisation process that will seek to improve living conditions in displacement.







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Simple Shelter Development Tool

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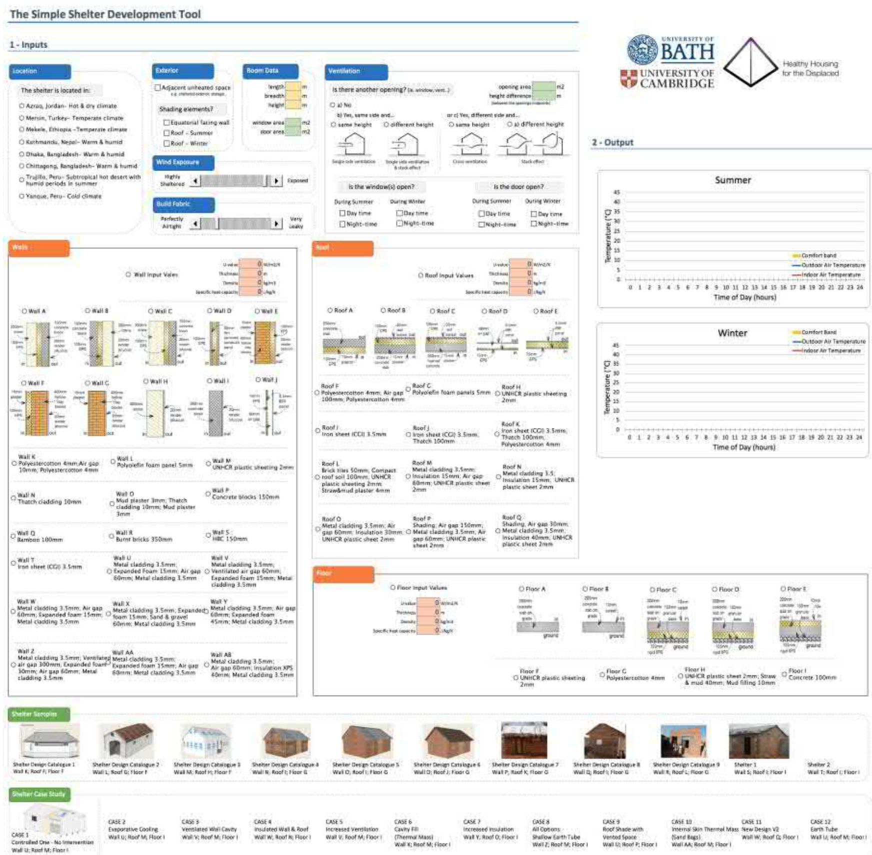

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Simple Shelter Development Tool

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1 - Inputs

Location

The shelter is located in:

- ◯ Azraq, Jordan– Hot & dry clima
- ◯ Mersin, Turkey– Temperate cli
- ◯ Mekele, Ethiopia –Temperate c
- ◯ Kathmandu, Nepal– Warm & hu
- ◯ Dhaka, Bangladesh– Warm & h
- ◯ Chittagong, Bangladesh– Warn
- ◯ Trujillo, Peru– Subtropical hot humid periods in summer
- ◯ Yanque, Peru– Cold climate

Exterior

- ☐ Adjacent unheated space
  e.g. sheltered exterior; storage...

Shading elements?

- ☐ Equatorial facing wall
- ☐ Roof – Summer
- ☐ Roof – Winter

Room Data

length m
breadth m
height m

window area m2
door ar

Wind Exposure

Highly Sheltered

Build Fabric

Perfectly Airtight

Ventilation

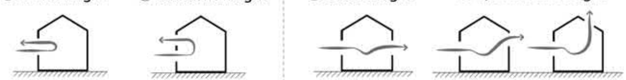
Is there another opening? (ie. window, vent...)

opening area m2
height difference m
(between the openings midpoints)

◯ a) No

b) Yes, same side and...
◯ same height ◯ different height

or c) Yes, different side and...
◯ same height ◯ a) different height



Single side ventilation | Single side ventilation & stack effect | Cross ventilation | Stack effect

Is the window(s) open?

During Summer
- ☐ Day time
- ☐ Night-time

During Winter
- ☐ Day time
- ☐ Night-time

Is the door open?

During Summer
- ☐ Day time
- ☐ Night-time

During Winter
- ☐ Day time
- ☐ Night-time

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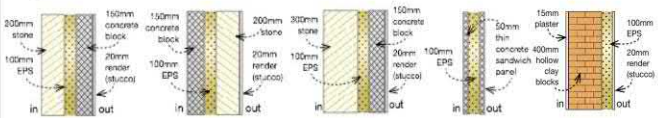
Walls

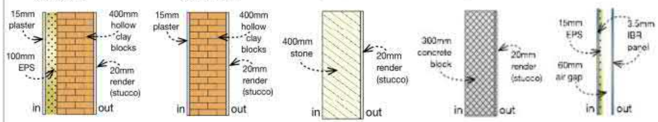
○ Wall Input Vales

U-value	0	W/m2/K
Thichness	0	m
Density	0	kg/m3
Specific heat capacity	0	J/kg/K

○ Wall A ○ Wall B ○ Wall C ○ Wall D ○ Wall E



○ Wall F ○ Wall G ○ Wall H ○ Wall I ○ Wall J

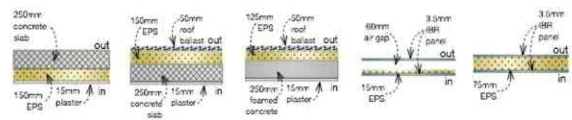


Roof

○ Roof Input Values

U-value	0	W/m2/K
Thichness	0	m
Density	0	kg/m3
Specific heat capacity	0	J/kg/K

○ Roof A ○ Roof B ○ Roof C ○ Roof D ○ Roof E



○ Roof F
Polyestercotton 4mm; Air gap 100mm; Polyestercotton 4mm

○ Roof G
Polyolefin foam panels 5mm

○ Roof H
UNHCR plastic sheeting 2mm

○ Roof I
Iron sheet (CGI) 3.5mm

○ Roof J
Iron sheet (CGI) 3.5mm; Thatch 100mm

○ Roof K
Iron sheet (CGI) 3.5mm; Thatch 100mm; Polyestercotton 4mm

Shelter Samples

Shelter Design Catalogue 1 — Wall K; Roof F; Floor F
Shelter Design Catalogue 2 — Wall L; Roof G; Floor F
Shelter Design Catalogue 3 — Wall M; Roof H; Floor F
Shelter Design Catalogue 4 — Wall N; Roof I; Floor G
Shelter Design Catalogue 5 — Wall O; Roof I; Floor G
Shelter Design Catalogue 6 — Wall O; Roof J; Floor G
Shelter Design Catalogue 7 — Wall P; Roof K; Floor G
Shelter Design Catalogue 8 — Wall Q; Roof I; Floor G
Shelter Design Catalogue 9 — Wall R; Roof L; Floor G
Shelter 1 — Wall S; Roof I; Floor I
Shelter 2 — Wall T; Roof I; Floor I

Shelter Case Study

CASE 1 — Controlled One - No Intervention — Wall U; Roof M; Floor I
CASE 2 — Evaporative Cooling — Wall U; Roof M; Floor I
CASE 3 — Ventilated Wall Cavity — Wall V; Roof M; Floor I
CASE 4 — Insulated Wall & Roof — Wall W; Roof N; Floor I
CASE 5 — Increased Ventilation — Wall V; Roof M; Floor I
CASE 6 — Cavity Fill (Thermal Mass) — Wall X; Roof M; Floor I
CASE 7 — Increased Insulation — Wall Y; Roof O; Floor I
CASE 8 — All Options: Shallow Earth Tube — Wall Z; Roof M; Floor I
CASE 9 — Roof Shade with Vented Space — Wall U; Roof P; Floor I
CASE 10 — Internal Skin Thermal Mass (Sand Bags) — Wall AA; Roof M; Floor I
CASE 11 — New Design V2 — Wall W; Roof Q; Floor I
CASE 12 — Earth Tube — Wall U; Roof M; Floor I

WP3: Prototyping & Physical solutions

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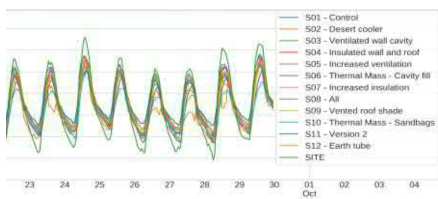
Prototype, measure, and develop novel combinations of conventional and non-conventional materials appropriate for a range of climatic, social, political, and economic conditions.

Room 1 "Indoor"		
Temp. range:	+40C	+5C
RH% range:	10%	95%
Room 2 "Outdoor"		
Temp. range:	+40	-20C
RH% range:	10%	95%
Pressurisation range	<250 N/m^2 (not with humidity)	
Rain simulation	Approx. 0.1 L/min	
IR radiation	1,200 W/m^2 @ 1m	



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WP4: PDWs and SAM

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Shelter Assessment Matrix (SAM) should be language-localised, extreme climate building physics-based, culturally sensitive, through Participatory Design Workshops.







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WP5: Material supply

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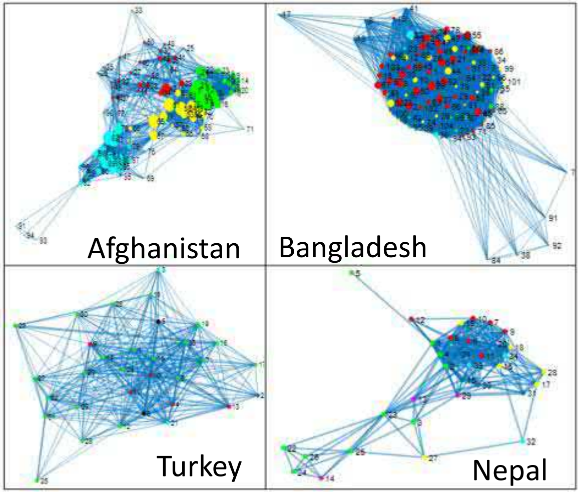
Examine the material supply networks in the construction of disaster relief shelters. Identify the purchasing patterns of the families and key influencing factors on family decision making in relation to procurement. This will help to speed up the delivery of novel solutions.



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Origins of SAM

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	Climate		
Location(s) Site data:	**Seasonal**	**Diurnal**	**Extremes**
Tmax			
Tmin			
Insolation			
RH			
Precipitation			
Vmax Wind speeds			
Sand storms			
Flood risk			
Seismic risk			

Privacy			
Appropriate			
Visibility (safety within camp)			
Privacy/partitioning within shelter			
Customisable			
Gender	Washing	Socialising	safe areas

Comfort					
Target temperature range(s) &	Seasonal	Diurnal			
Adaptive comfort	Ambient	Radiant			
Ventilation	O_2	CO_2	Other		
Air Quality	VOC	Cooking	Sanitation	Incidental	Carcinogens
Acoustic	Attenuation	Quiet spaces	Privacy	Security	Mass vs attenuation
Humidity	Max	Min			
Lighting	Daylight	Sunlight	artificial	nightime?	Genaral/task
Ergonomic/Anthropometric	User friendly space	Adaptable space			
Psychological	Promotes wellbeing	Maintains wellbeing	Community engendered		

Safety			
Indivudual(s)			
Families			
Fire risk			
Criminal activity			
Visibility (women in isolation)			

Generations	Groups	Mixed	Childcare	Education	Cultural

Design	Multi-criteria Design Tool	Prioritise key components	I.D core common elements	Adaptive Kit of parts

Construction	On-site	Off-site					
Size	Area (m^2)	Modular bay Dimensions	Area around shelter				
Cost	£/shelter	Operational Energy	Embodied C	Transport			
Stability	Wind load	Storm load	Sand storms	Flood	Earthquakes	UV	
Speed of construction/deconstruction	Stage 1. Weathertight	Stage 2. "Completion"	Stage 3. Adaptation	Deconstruction			
Materials	Politically/socially Appropriate	Weathertight	Local/Available	Durable	Weathertight	Insulating, (thermal/acoustic)	Transportable
Re-useable	0 to 5?	5 to 10?					
Life-expectancy	0-5 yrs	5-10 yrs					
Maintenance	Cleaning	Repair					
Adaptable/flexible/modular	Spatial	Functional	Divided	Enlarged	Customisable	Public/private spaces	Mono/multicultural needs
Accessibility	Young	Old	Disabled	Injured	Groups		

Infrastructure	Sanitation	Services?	Local Regs	Local Authorities

Output parameters from 1st Industrial Steering Committee meeting

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Shelter Input Details

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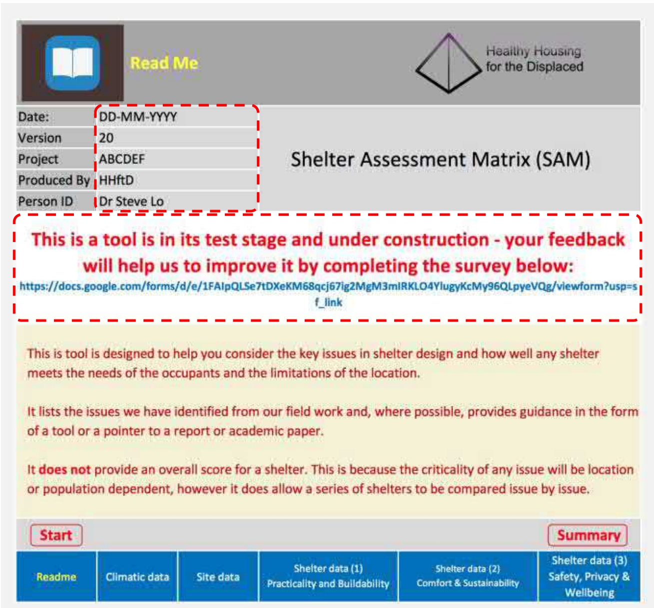


Read Me

Healthy Housing for the Displaced

Date:	DD-MM-YYYY
Version	20
Project	ABCDEF
Produced By	HHftD
Person ID	Dr Steve Lo

Shelter Assessment Matrix (SAM)

This is a tool is in its test stage and under construction - your feedback will help us to improve it by completing the survey below:

https://docs.google.com/forms/d/e/1FAIpQLSe7tDXeKM68qcj67ig2MgM3mIRKLO4YlugyKcMy96QLpyeVQg/viewform?usp=sf_link

This is tool is designed to help you consider the key issues in shelter design and how well any shelter meets the needs of the occupants and the limitations of the location.

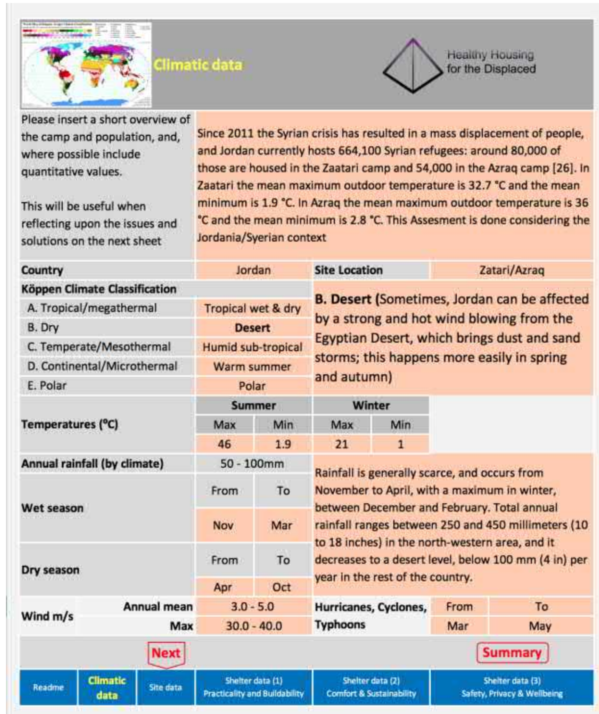
It lists the issues we have identified from our field work and, where possible, provides guidance in the form of a tool or a pointer to a report or academic paper.

It **does not** provide an overall score for a shelter. This is because the criticality of any issue will be location or population dependent, however it does allow a series of shelters to be compared issue by issue.

Start | Summary

Readme | Climatic data | Site data | Shelter data (1) Practicality and Buildability | Shelter data (2) Comfort & Sustainability | Shelter data (3) Safety, Privacy & Wellbeing

NOT a design solution
but an assessment tool



Climatic data

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Please insert a short overview of the camp and population, and, where possible include quantitative values.

This will be useful when reflecting upon the issues and solutions on the next sheet

Since 2011 the Syrian crisis has resulted in a mass displacement of people, and Jordan currently hosts 664,100 Syrian refugees: around 80,000 of those are housed in the Zaatari camp and 54,000 in the Azraq camp [26]. In Zaatari the mean maximum outdoor temperature is 32.7 °C and the mean minimum is 1.9 °C. In Azraq the mean maximum outdoor temperature is 36 °C and the mean minimum is 2.8 °C. This Assesment is done considering the Jordania/Syerian context

Country	Jordan		Site Location	Zatari/Azraq
Köppen Climate Classification				
A. Tropical/megathermal	Tropical wet & dry			
B. Dry	**Desert**			
C. Temperate/Mesothermal	Humid sub-tropical			
D. Continental/Microthermal	Warm summer			
E. Polar	Polar			

B. Desert (Sometimes, Jordan can be affected by a strong and hot wind blowing from the Egyptian Desert, which brings dust and sand storms; this happens more easily in spring and autumn)

	Summer		Winter	
Temperatures (°C)	Max	Min	Max	Min
	46	1.9	21	1
Annual rainfall (by climate)	50 - 100mm			
Wet season	From	To		
	Nov	Mar		
Dry season	From	To		
	Apr	Oct		
Wind m/s — Annual mean	3.0 - 5.0			
Wind m/s — Max	30.0 - 40.0			

Rainfall is generally scarce, and occurs from November to April, with a maximum in winter, between December and February. Total annual rainfall ranges between 250 and 450 millimeters (10 to 18 inches) in the north-western area, and it decreases to a desert level, below 100 mm (4 in) per year in the rest of the country.

Hurricanes, Cyclones, Typhoons	From	To
	Mar	May

Next | Summary

Readme | Climatic data | Site data | Shelter data (1) Practicality and Buildability | Shelter data (2) Comfort & Sustainability | Shelter data (3) Safety, Privacy & Wellbeing

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Shelter Input Details

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Site data

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Population Narrative:			
Nature of displacement	Displaced by civil war		
Rural or urban populations	Equal numbers of rural and urban population		
Religious mix	Mostly Islamic		
Age distribution	Normal distribution of ages		
Gender distribution	Equal distribution of male & female		
Site Name	Azraq and Zatari camp		
Local Government/Agency issues	That housing should look temporary, so no use of brick or blockwork.		
Soil type	Sand	Anyone who has visited the camps from WPs 1-4 can populate this to create a library of different sites.	
Topology	Flat		
Ease of laying concrete pad	Flat		
Notes:	Sand with impenetrable rock at 30cm deep		
Access to local materials	Structural	Panels	Insulation/Mass
	Steel	None	Insulation
Notes:	Steel tubing		IBR Cladding
Utilities	Gas	Electricity	Water
	Bottled gas	None	None
Notes:	All shelters given bottled gas	Plans to distribute electricity, long term	
Access to cooking fuel	None	Notes: Add here	
The Displaced	Assumed No./shelter	Space Requirements	Water
	3 - 5	<3.5m2/person	None
Notes:			
Add other variables here			
Notes:			

Next | Summary

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Shelter data
1. Practicality & Buildability

Healthy Housing for the Displaced

Basic Shelter requirements	The shelters should be able to maintain reasonable comfort conditions throughout the year: Ideally within the range 10ºC to 30ºC and 30% to 70% RH. A particular focus on issues of female privacy wrt those outside the shelter.
Required sub-divisions	At least 2 compartments
Shelter name	Enter the name of shelter

Design criteria	Issue	Details	Rating criteria	Importance of sub-issue: 0=n/a 1=Slight 2=Moderate 3=Important 4=Critical	How well does the shelter resolve sub-issue: 1= Poor Up to 5=Very Good	Supporting evidence: 1. Modelling 2. Prototype testing 3. Established on-site performance	Performance of shelter per design criteria
Pre-construction	Cost	What's the approximate cost per shelter, fully constructed?	1. Equal or above 5,000 USD 2. Between 3000 to 4,000 USD 3. Between 2000 to 3,000 USD 4. Between 1000 & 2,000 USD 5. Equal or Below 1,000 USD	4	3	1 2 & 3	[illegible]
	Ease of Delivery	How easy is it to deliver and distribute shelter?	1. Requires specialist heavy lifting equipment (crane, forklift) 2. Requires large vehicle/trailer 3. Requires no lifting equipment but a small truck, and 4-6 people per shelter 4. Can be handled manually 5. Fabricated on site using locally available materials	3	4	3	11
Construction & Flexibility	Ease of construction	How many people are needed to construct one shelter? Are specialist skills/tools/equipment required/supplied with each shelter?	1. Requires specialist skills/tools and equipment). 2. Requires trained/skilled personnel to construct 3. Requires at least 4 people/moderate training & knowledge of construction/accessible tools). 4. Can be constructed by 3-4 untrained people 5. Does not require any specialist tools or training and can be constructed by fewer than 3 people).	4	4	1 & 2	16
	Speed of construction	How long does it take to construct a complete single shelter?	1. More than 7 days 2. 3 to 7 days 3. 1 to 2 days 4. 6 hours to a day 5. Less that 6 hours	4	4	3	16
		Is constructing the shelter in stages desired? If yes how well does the shelter address this requirement? If no choose 0 = n/a in column G.	1. Not possible to build the shelter in stages 2. Not designed to be built in stages but its possible with significant increase in resources 3. Not designed to be built in stages but possible with moderate increase in resources 4. Can be built in stages with some minor efforts by the beneficiary 5. Integral design feature	0	1	2	0
	Adaptability	How easy is it to adapt the shelter to suit different beneficiary requirements? (How much freedom does the shelter beneficiary have to customise the shelter with given resources?)	1. Very difficult or not possible to do adaptations without compromising the structure). 2. Limited adaptability/customisation possible (e.g. only internal adaptations possible/ adding elements or zones). 3. External/internal adaptation is possible but might require careful consideration to avoid compromises to the structure. 4. Alteration to footprint of the building is possible (adding or removing a room) might require resources to do so. 5. Adaptability is an integral design feature (e.g. swap panels/move partitioning/ create windows/modular design).	3	3	1	[illegible]
		Will structure support hanging (heavy) items?	1. Can only support less than 5kg 2. Can support between 5-10kg 3. Can support 10 to 15kg 4. Can support 15 to 30kg 5. Can support more than 50kgs	3	2	1	[illegible]
		Can structure accommodate shelves/storage?	1. No, (domed/curved shelters OR weak structure) 2. Possible but requires specialist tools to do so 3. Possible but requires certain sections/or possible but with difficulty) 4. Geometrically easy to attached/modify or strong structure) 5. Has space designed for storage	3	3	1	[illegible]
	Scalable	Is the design scalable to allow use by larger families or for other purposes such as healthcare facility, school, community space.	1. No (It take less efforts to build something completely different than to scaling the design of this shelter) 2. Possible with major reworking (requires specialist skills to do so) 3. Possible with minor reworking (e.g. requires extensive labour work only) 4. Yes but the scaling factor is limited 5. Yes, (An integral design feature)	1	3	1	[illegible]
Lifetime & Maintenance	Durability	What's the life span of the structure/skin of the shelter?	1. Up to 1 year 2. Between 2-3 years 3. Between 3-5 years 4. Between 5 to 7 years 5. Between 7 to 10 years	4	1	3	[illegible]
	Ease of repairs	Is it to repair the shelter/Can the occupant repair the shelter themselves or are specialist tools required?	1. No (not repairable) 2. Can be repaired but requires skilled personnel and tools/equipment 3. Can be repaired but requires skilled personnel only 4. Easy but requires specific materials which is not easily available 5. Easy (only needs commonly available tools & no specialist knowledge/skills)	4	1	1 & 2	[illegible]
	Cleaning	Is it easy to keep the walls clean?	1. Difficult (not designed to be cleaned its just disposable) 2. Not a smooth texture but stains can be cleaned (Possible to clean with effort and cleaning products e.g. plastered walls) 3. Can be cleaned but would require significant amount of efforts 4. Easily cleanable but might requires cleaning products 5. Easy (wipable smooth surfaces/ requires dry or wet cloth only/ or surfaces made of ceramic tiles/ composite plastic finish)	3	4	3	12
		Is it easy to keep the floor clean?		3	2	1	[illegible]

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Shelter Input Details

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Shelter data

1. Practicality & Buildability

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Pre-construction	Cost	What's the approximate cost per shelter, fully constructed?	1. Equal or above 5,000 USD 2. Between 3000 to 4,000 USD 3. Between 2000 to 3,000 USD 4. Between 1000 & 2,000 USD 5. Equal or Below 1,000 USD	4	5	1 2 & 3	[illegible]
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Supporting Tools

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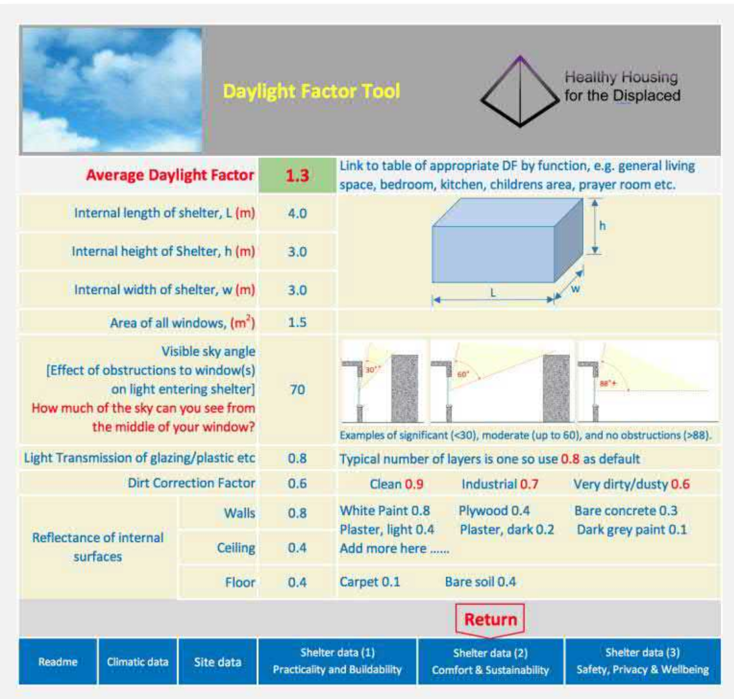

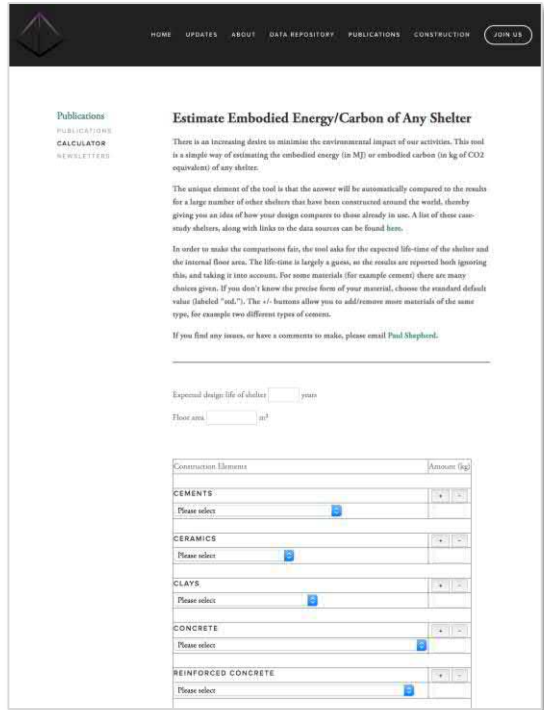

Healthy Housing for the Displaced

Key Input Categories

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Pre-construction
- Cost
- Ease of Delivery
- Assembly

Construction& Flexibility
- Ease of Construction
- Speed of Construction
- Adaptability
- Scalability

Lifetime & Maintenance
- Durability
- Ease of Repairs
- Cleaning

Comfort
- Air Quality
- Daylighting
- Thermal Performance

Sustainability
- Reusability
- Recyclability
- Env. Impact
- Locality
- Renewables

Safety
- Security
- Fire Resistance
- NH Resistance

Protection
- Weather Tightness
- Insects
- Vermin
- H&S

Privacy
- Acoustic attenuation
- Visibility

Well-being& Adaptability
- Cultural aspects
- Disabled access
- Social Provision

Healthy Housing for the Displaced

Output Options (1)

UNIVERSITY OF BATH

Shelter Data Summary

Healthy Housing for the Displaced

Shelter Name All-singing, all dancing, go anywhere, build-anywhere shelter, Ltd

	Max	Score	
Pre-construction	35	32	91%
Construction & Flexibility	90	47	52%
Lifetime Maintenance	70	26	37%
Comfort	125	28	22%
Sustainability	90	30	33%
Safety	65	18	28%
Protection	75	38	51%
Privacy	65	19	29%
Well-being & Adaptability	80	20	25%

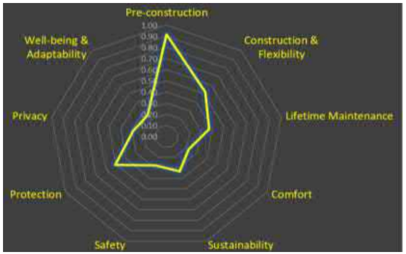
Readme	Climatic data	Site data	Shelter data (1) Practicality and Buildability	Shelter data (2) Comfort & Sustainability	Shelter data (3) Safety, Privacy & Wellbeing

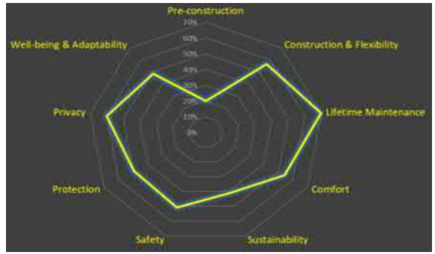
	Max	Score	
Pre-construction	35	25	72%
Construction & Flexibility	90	42	47%
Lifetime Maintenance	70	46	66%
Comfort	125	68	54%
Sustainability	90	26	29%
Safety	65	47	72%
Protection	75	45	60%
Privacy	65	26	40%
Well-being & Adaptability	80	21	26%

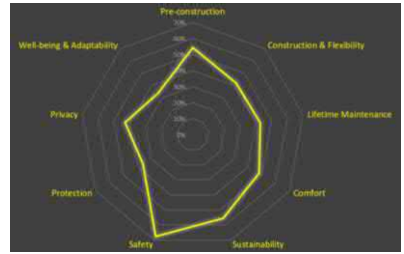
	Max	Score	
Pre-construction	35	7	20%
Construction & Flexibility	90	48	53%
Lifetime Maintenance	70	46	66%
Comfort	125	74	59%
Sustainability	90	44	49%
Safety	65	35	54%
Protection	75	54	72%
Privacy	65	42	65%
Well-being & Adaptability	80	55	69%

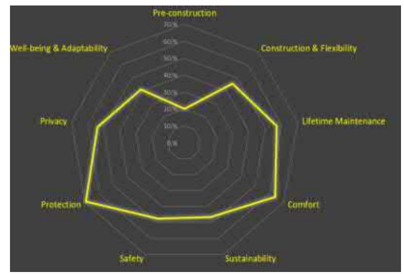
	Max	Score	
Pre-construction	35	7	20%
Construction & Flexibility	90	51	57%
Lifetime Maintenance	70	49	70%
Comfort	125	68	54%
Sustainability	90	37	41%
Safety	65	33	51%
Protection	75	37	49%
Privacy	65	39	60%
Well-being & Adaptability	80	39	49%

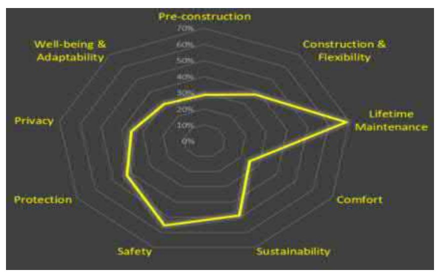
Output Options (2)

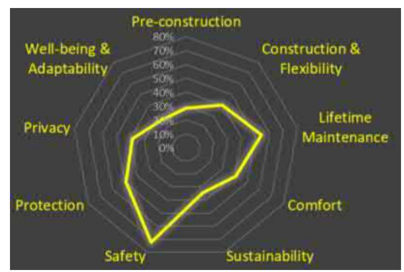












SAM Feedback

Healthy Housing for the Displaced

UNIVERSITY OF BATH

We need your help and support.
We want to develop this tool **with the aid sector not for the aid sector.**

Help us by completing the survey at the link below:

https://docs.google.com/forms/d/e/1FAIpQLSe7tDXeKM68qcj67ig2MgM3mIRKLO4YlugyKcMy96QLpyeVQg/viewform

Test the SAM and provide us with feedback