Flood Resilient Shelter Research *Pakistan*

Tim White
Arup International Development

Background

3

years of extreme flooding

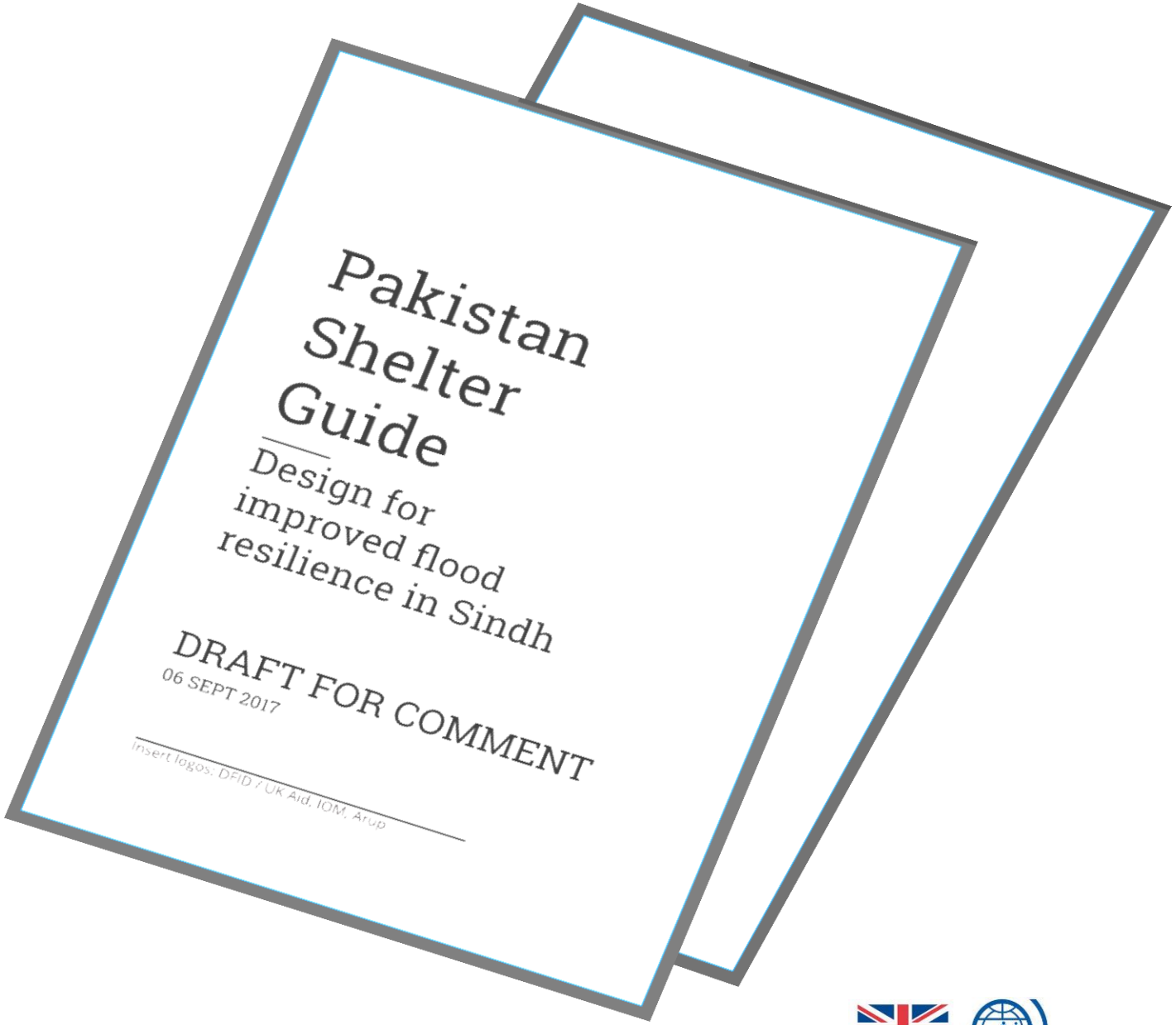
18

million affected

Introduction

Two outputs:

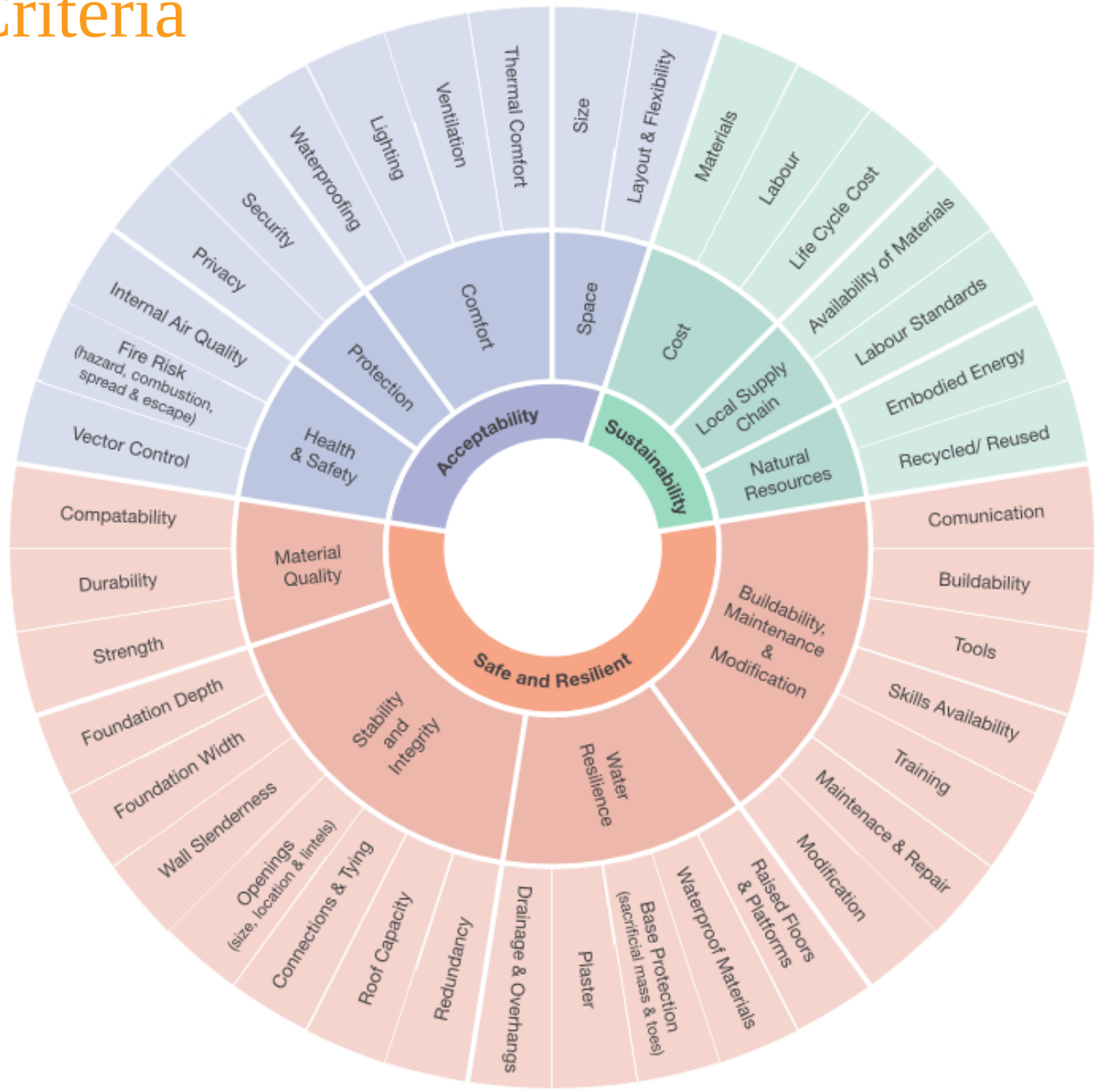
1. **Research Report**
   a) Methodology
   b) Key findings
2. **Shelter Guide**
   a) Recommendations



UKaid from the British people
IOM • OIM
ARUP

Research Report

Rigour – Key Criteria

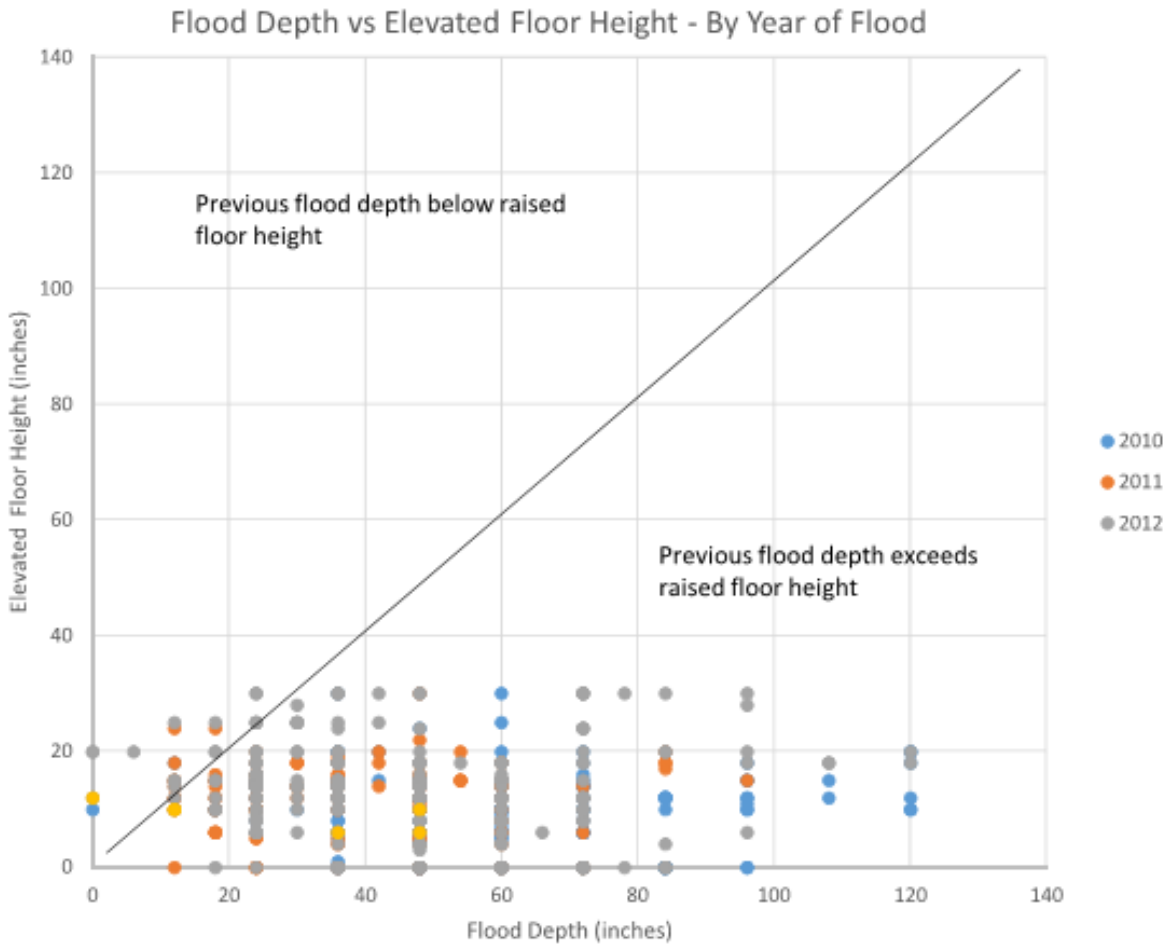


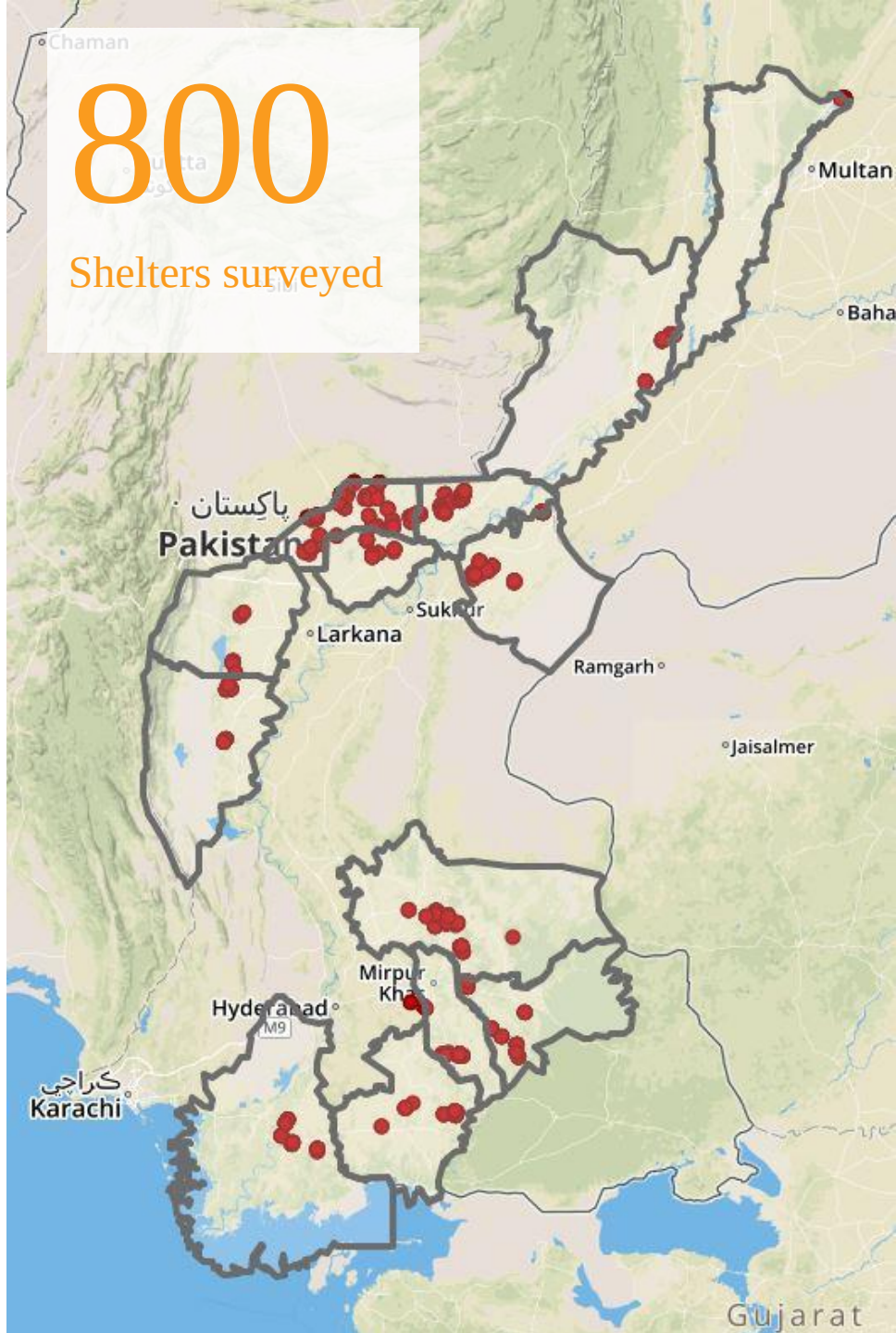
Rigour - Metrics

Variable	Qualitative Metric	Quantitative Metric	Baseline
Waterproof materials	**Standing water:** Are the foundations built from waterproof materials? Are waterproof materials used up to the past/future flood level? **Loh Kat:** Are frame structures able to withstand immersion?	**Standing water:** To what height are the materials used waterproof?	**Loadbearing construction:** materials must be waterproof to level above flood otherwise the structure will fail. **Loh-kat:** Frame to be constructed of rot resistant timber/bamboo
Sacrificial protection	**Heavy rain:** Are the outsides of the walls plastered? If mud plaster is used has it been stabilised? If a mud roof is used has it been stabilised? If using earthen walling is sacrificial mass provided at the base of the shelter? Is the sacrificial mass stabilised?	N/A	Walls should be plastered to provide a sacrificial wearing layer that can be repaired without the wall structure being damaged Earth plasters that are stabilised with lime or cement will require less frequent repair Sacrificial mass in the form of 'toes' provided at the base of a shelter will protect the base against heavy rainfall
Overhangs	N/A	**Heavy rain:** Are the tops of earthen walls protected by a roof overhang?	0.3H over hang
Drainage	**Heavy rain:** Is the base designed to prevent standing water? Is the roof designed to prevent standing water? If a mud roof is used has it been stabilised?		The base of a shelter should slope away from the walls Roof drainage details are included Adding lime to a mud roof will improve its water resistance, improving drainage by reducing water seeping it

UKaid from the British people
IOM • OIM
ARUP

Evidence base – Field surveys





Evidence base - Flood and rain testing

24

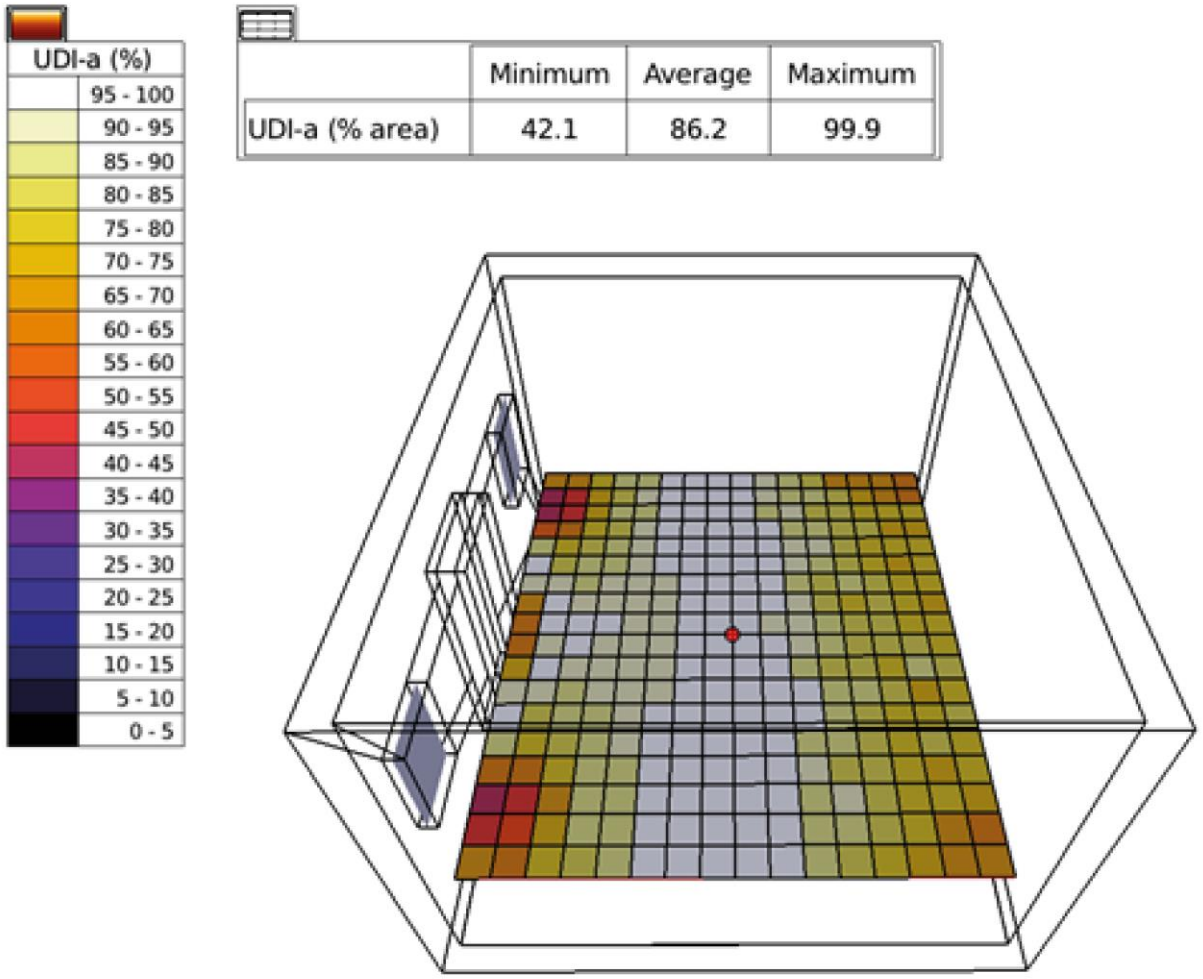
full scale
panels tested

Evidence base – Analytical studies

5

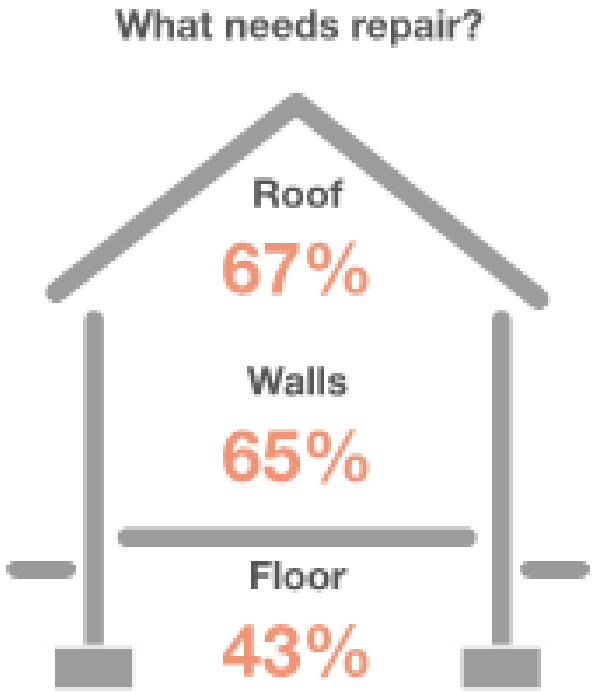
Analysis desk studies

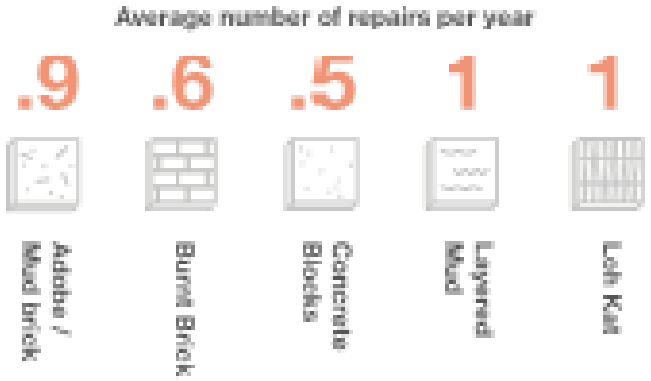
- Cost
- Sustainability
- Structural
- Thermal/Ventilation
- Daylighting

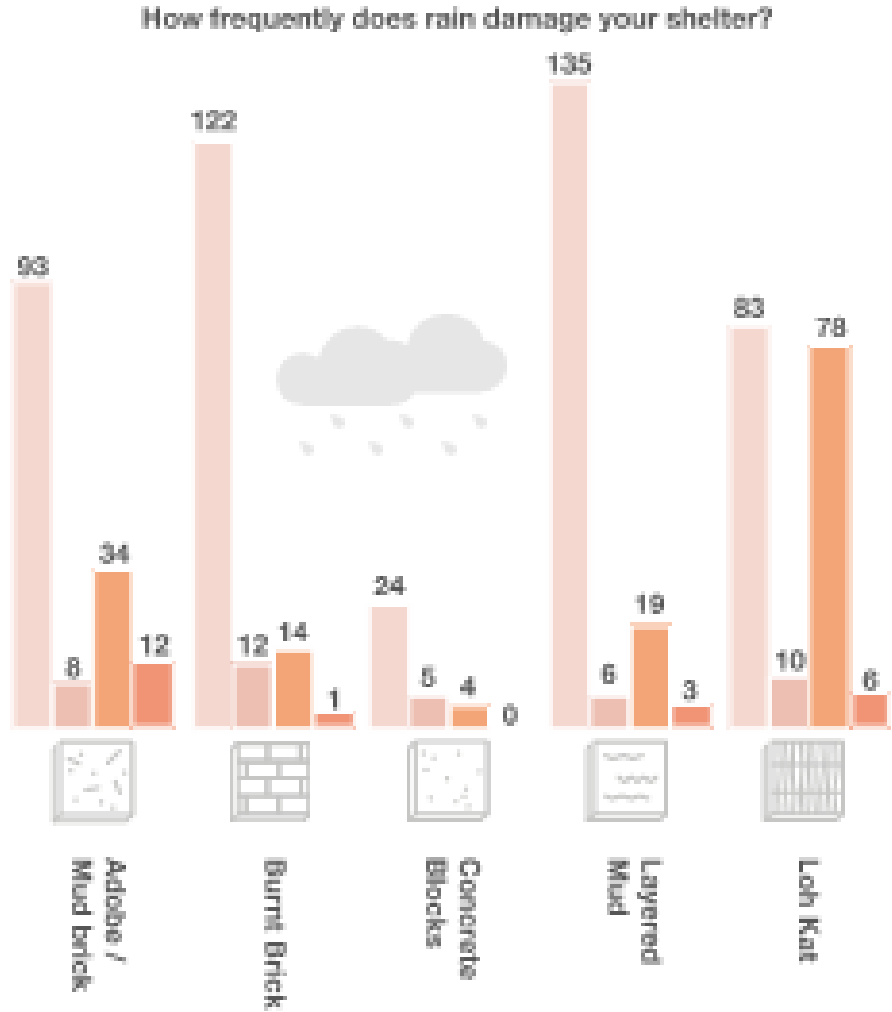


	Minimum	Average	Maximum
UDI-a (% area)	42.1	86.2	99.9

Key findings







UKaid from the British people

IOM • OIM

ARUP

Shelter Guide

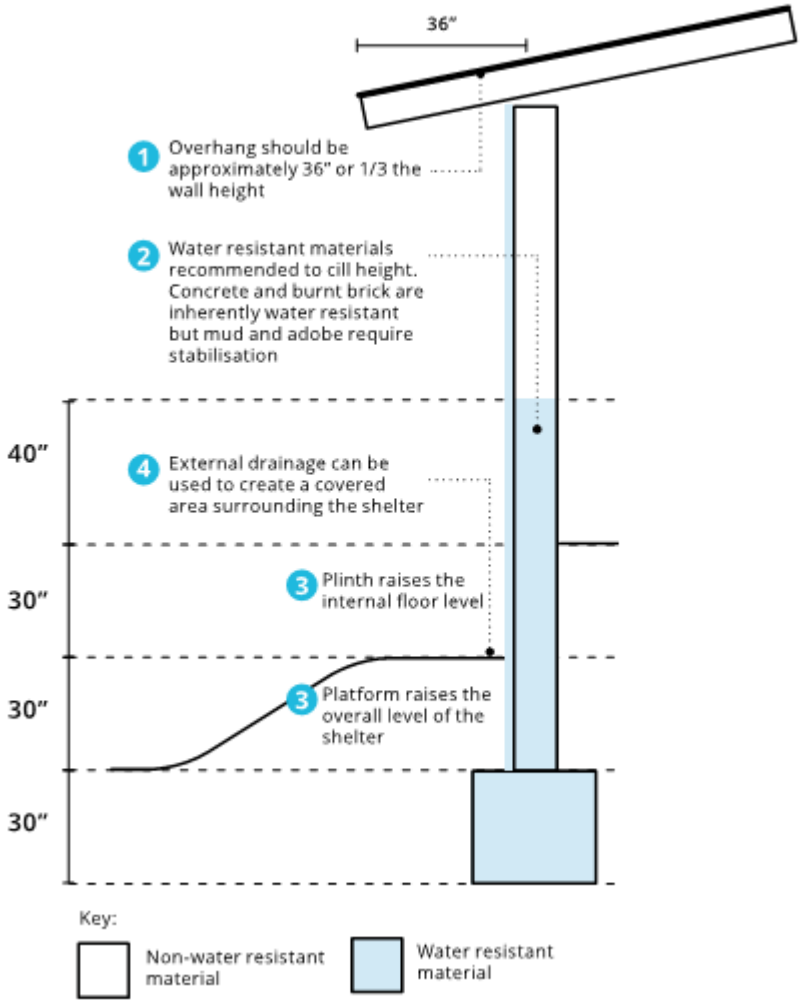
Shelter Guide

1. Design principles
2. **Design decision tool**
3. **Design information**
4. Supporting information

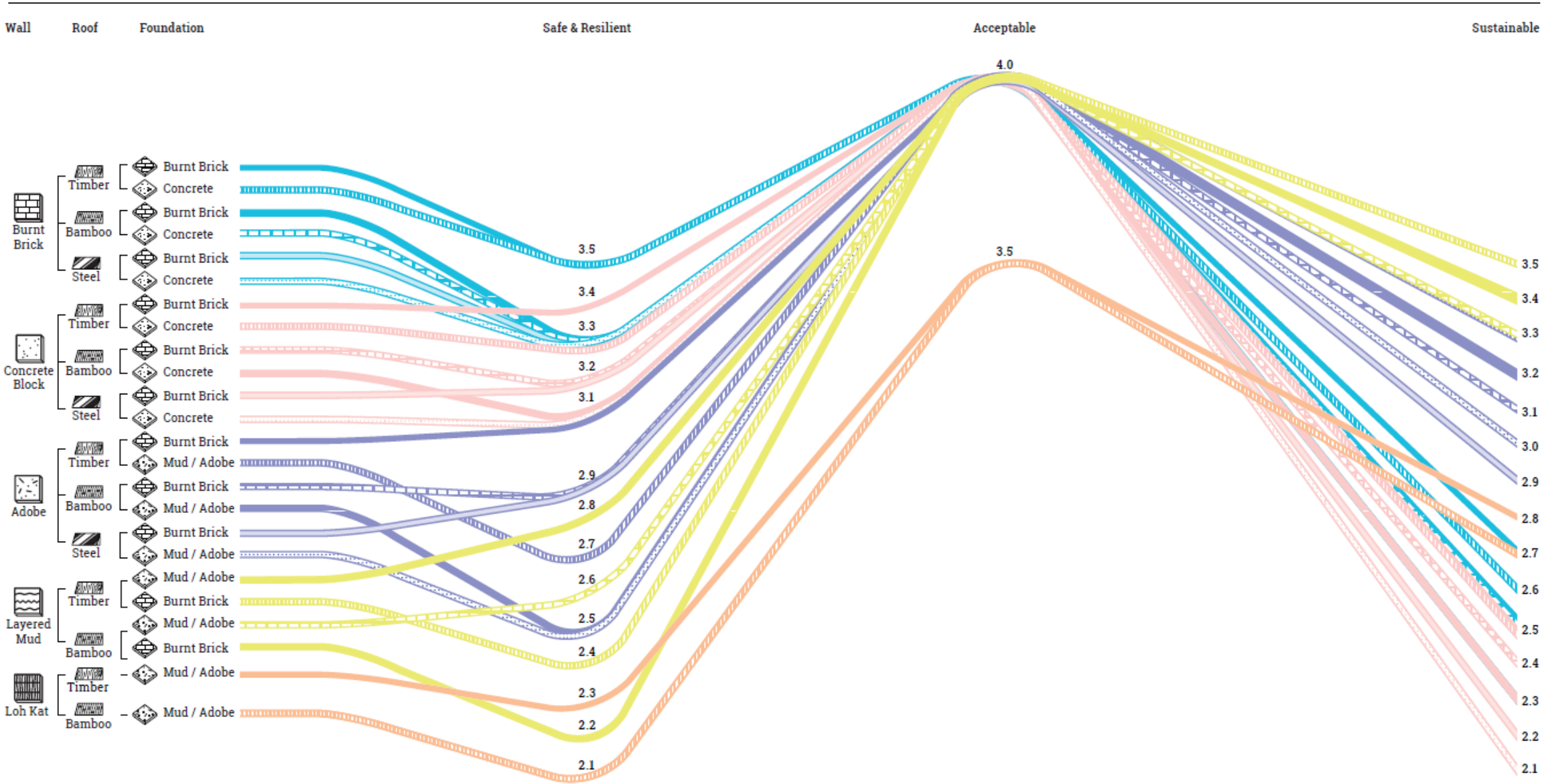
Design Principles

- Water resistant foundations
- Water resistant walls
- Plinth and platform (and shelf and roof)

- Roof overhang
- Water resistant plaster
- External drainage



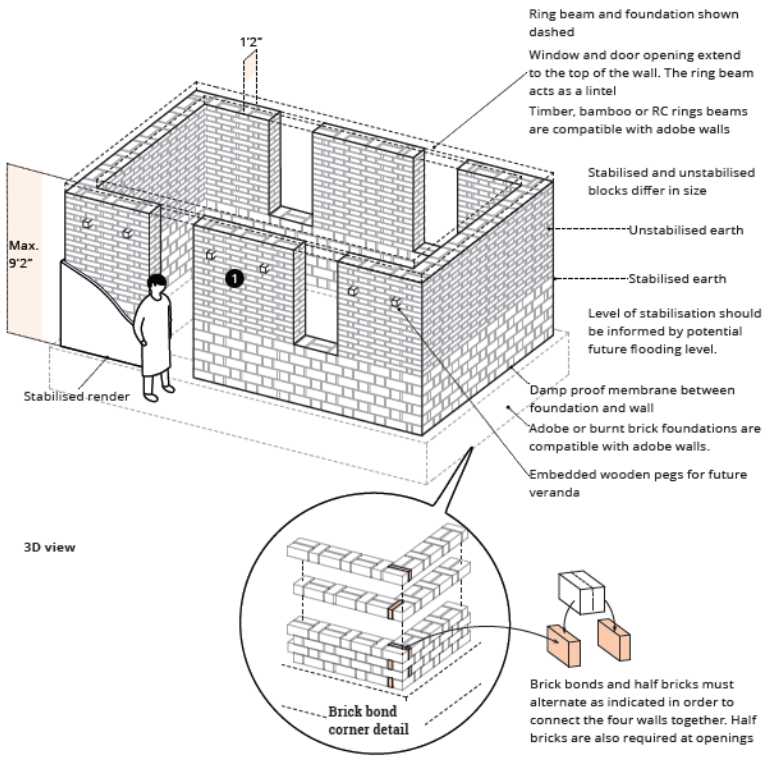
Design Decision Tool



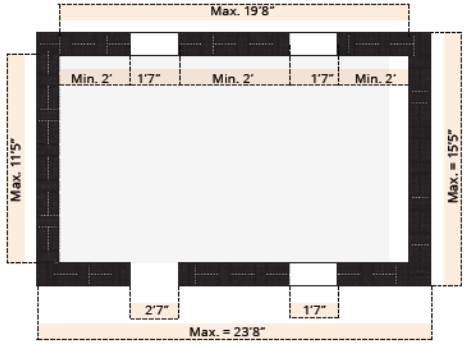
Design Information

Adobe

Wall Component

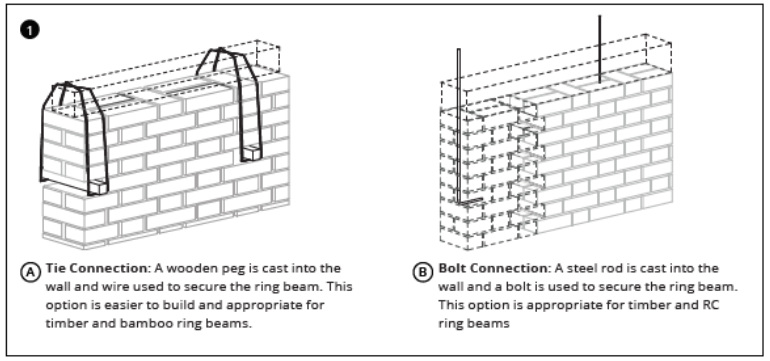


3D view



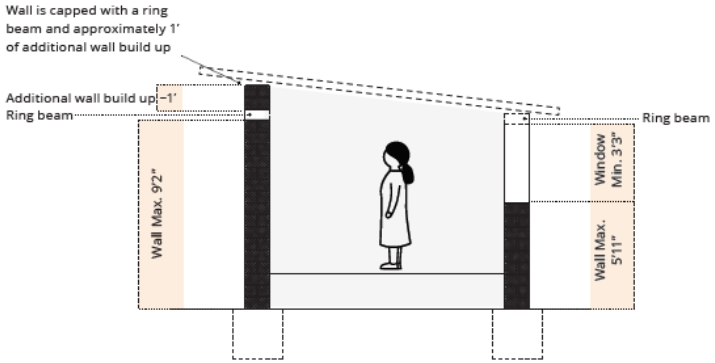
Plan [not to scale]

Seismic consideration: Sindh is a region of moderate to high seismicity. Seismic design is outside the scope of this guide, the following measures will improve seismic performance. The following is recommended: Remove front window; Use a reinforced concrete ring beam; Use piers at the corners and in the middle of the long wall. For more information see Design Information, Seismic page



Ⓐ **Tie Connection**: A wooden peg is cast into the wall and wire used to secure the ring beam. This option is easier to build and appropriate for timber and bamboo ring beams.

Ⓑ **Bolt Connection**: A steel rod is cast into the wall and a bolt is used to secure the ring beam. This option is appropriate for timber and RC ring beams



Section [not to scale]

Variation
Cement for stabilisation:
+ Buildability
- Sustainability
Bolt connection:
+Stability
- Buildability

Health and Safety
Lime/Cement used in stabilisation burns. Wear gloves.

Specification
Earth block Production
Plaster

Thankyou for listening

For comments or queries, please contact

tim.white@arup.com