HOW TO ADAPT YOUR HOUSE TO CLIMATE CHANGE

TECHNIQUES AND RECOMMENDATIONS
**CLIMATE CHANGE**

**WHAT IS CLIMATE CHANGE?**

Climate Change is usually referred to as “changes in the weather patterns over an extended period of time” that a given region experiences due to an increase in the Earth’s average temperature. This can mean more or less precipitation, untimely snowfall, an increase in extreme weather events such as storms, floods and droughts, etc. Climate Change is caused due to an increase in the concentrations of Greenhouse Gases (GHGs like CO2, CH4, N2O, HFCs and SF6), which leads to an increased Greenhouse Effect.

**IMPACTS OF CLIMATE CHANGE IN THE WESTERN INDIAN HIMALAYAS**

- **Glacier melting**
  - 1948
  - 2006
  - Trift-Glacier, Switzerland

- **Shift in apple belt**
  - Before: 9,000 ft
  - Now: 12,000 ft
  - 13.7º before 2000
  - 14.5º before 2100
  - 17.3º after 2100

- **Shorter Chadar trek**
  - Before:
    - Nov
    - Dec
    - Jan
    - Feb
    - Mar
    - May
  - Now:
    - Nov
    - Dec
    - Jan
    - Feb
    - Mar
    - May

- **More frequent floods**
  - 1948
  - 2006

- **Changes in precipitation**

**CONSEQUENCES ON HOUSING**

- Heavier, more frequent and irregular rainfall ➡️ Water leakages from the roof and structure damage
- High risk of floods ➡️ Structure damage (foundations, walls) until complete destruction
Several efficient technical solutions exist in the Western Indian Himalayas to ensure a waterproof roof. Three of them, whose effectiveness facing heavy rainfall has already been proven and tested on the field, are described in the following pages:

- Polythene sheet;
- Galvanized Iron (GI) sheet;
- Clay.

These technical solutions can be implemented in both new and retrofitted houses.

### Polythene Sheet Waterproofing

This solution uses a polythene sheet as waterproof layer for traditional flat roofs. Above the usual layers of the roof the following layers have to be implemented:

- A polythene sheet (3) between two layers of sandy soil (without gravel) (2) & (4) to protect it;
- A layer of mud (1) to finish the roof.

### Advantages

- Easy implementation
- Affordable

### Drawbacks

- Risk of condensation within the roof for wet rooms (kitchen, bathroom,..) if layers of sandy soil (4) + mud (5) between insulator (6) and polythene sheet (3) are not implemented.
Avoid this solution for wet rooms (kitchen, bathroom) because of condensation risks. Water vapour created inside (by intense cooking for example) can get stuck to the plastic sheet and condensate within the roof. This could cause premature deterioration of the house structure (especially the insulator layer) and also degrade the indoor air quality.

If this solution is still chosen for a kitchen or bathroom, it is important to add a layer of sandy soil between the plastic sheet and the insulation layer to reduce condensation risks. Choose a waterproof insulator such as yakzes or burtsey.

**Slope of the roof**

If the roof is large, having only one slope can cause overload on one side of the house. In this case, use the beams instead of the mud layer to create the slope, or distribute the slope in different directions as shown below (slope = minimum 3%).

**Other implementation key points**

Corners between parapet and roof:
Join the corners between parapet and roof (b) with a layer of polythene sheet vertically along the parapets and fix it with mud (c). It is also advised to implement a sloped coping (a) on top of the parapet.

Drainage systems:
Install drainage systems to properly drain rain water. Without it, the risk of leakages is high. Two techniques can be implemented: drainage pipes (a) or galvanized iron sheets (b).

**Maintenance**

The roof should be checked at least once a year and after heavy rain. Particularly 3 points should be checked and fixed if needed: the waterproofing of corners (parapet/roof) and other singular parts (chimney...). The roof should remain sloped (minimum=3%) and drainage systems should not be obstructed.
Main materials and cost estimate  For a 30 ft x 30 ft roof

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Cost estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polythene sheet (1.20 gsm good quality)</td>
<td>950 sqft</td>
<td>4,275 INR</td>
</tr>
<tr>
<td>Plastic sheet transportation</td>
<td>-</td>
<td>Case to case</td>
</tr>
<tr>
<td>Skilled labor (to implement waterproof solution)</td>
<td>3 days</td>
<td>1,500 INR</td>
</tr>
<tr>
<td>Unskilled labor (to implement waterproof solution)</td>
<td>6 days</td>
<td>2,100 INR</td>
</tr>
</tbody>
</table>

NB: Prices based on Leh market 2011

**Galvanized Iron sheet waterproofing**

This technical solution consists of using Galvanized Iron (GI) sheet as a waterproof layer. Two techniques are widely implemented:

- GI sheet installed above beams of the roof (cf. photo 1)
- GI sheet installed above local roof (cf. photo 2)

**Advantages**
- Limited maintenance

**Drawbacks**
- Can change the house outer aesthetic if GI sheet is very sloped
- Very expensive

**Maintenance**

This type of roof doesn’t need regular maintenance as other roofs but it is advised to check quickly the entire roof every year to prevent problems.

Main materials and cost estimate  For a 30 ft x 30 ft roof using GI sheet above beams

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Cost estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GI sheet (24 gauge = 0.51 mm)</td>
<td>45 pieces</td>
<td>45,400 INR</td>
</tr>
<tr>
<td>Wooden timber (safeda)</td>
<td>17.5 cft</td>
<td>7,200 INR</td>
</tr>
<tr>
<td>Nails and washers</td>
<td>-</td>
<td>1,100 INR</td>
</tr>
<tr>
<td>GI sheet transportation</td>
<td>-</td>
<td>Case to Case</td>
</tr>
<tr>
<td>Skilled labor (to implement waterproof solution)</td>
<td>6</td>
<td>3,000 INR</td>
</tr>
<tr>
<td>Unskilled labor (to implement waterproof solution)</td>
<td>15</td>
<td>5,250 INR</td>
</tr>
</tbody>
</table>

NB: Prices based on Leh market 2011
This local solution uses clay as a waterproof layer for traditional flat roofs. The following layers are implemented above the existing roof:

- A layer of clay (2) that plays the role of waterproof layer;
- A layer of soil (1) that mostly plays the role of a protection layer for clay layer.

**Advantages**
- Double function:
  - Protects against rainfall;
  - Allows water vapour to escape, decreasing condensation risks.
- Affordable in most cases

**Drawbacks**
- Regular maintenance required

### Implementation key points

**Layer of clay (2):**
The thickness of the clay layer should be at least 2 inches. If good quality clay is not available, increase the thickness up to 3 or 4 inches. The clay should be crushed into small gravel and (if possible) mixed with yakzes (around 15% in volume) to bind/link it.

**Slope of the roof:**
The roof should have a proper slope (min = 3%) to drain the water. The slope can be created by the mud layer below clay (a). In case of overload on the thickest part of the roof, create the slope with beams (b) or distribute the slope in different directions (c).
Corners between parapet and roof:
This part should be waterproofed by joining the corners between the parapet and roof (b) using clay and implementing a sloped coping (a) on top of the parapet. Another technique is to add a plastic sheet in the periphery of the roof to protect the corners from rainfall.

Drainage systems:
The roof should have a drainage system to properly drain the water. Two techniques can be implemented: drainage pipes (a) or Galvanized Iron GI sheets (b).

Maintenance
The roof should be checked at least once a year and after heavy rain. Particularly 4 points should be taken into consideration: The corners (parapet/roof) and other singular parts (chimney...) should be checked and fixed if needed;
The roof should remain sloped (minimum 3%).
Drainage systems should not be obstructed;
The thickness of the soil (1) protection layer should remain 2 inches.

Main materials and cost estimate

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Cost estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay 2 inches thickness</td>
<td>150 cft</td>
<td>Free in most of cases</td>
</tr>
<tr>
<td>Yakzes to mix with clay. 15% in volume</td>
<td>22 cft</td>
<td>1,000 INR (free in most of cases)</td>
</tr>
<tr>
<td>Clay transportation</td>
<td>-</td>
<td>Case to Case</td>
</tr>
<tr>
<td>Skilled labor (for implementation)</td>
<td>3-4</td>
<td>1,500 to 2,000 INR</td>
</tr>
<tr>
<td>Unskilled labor (for implementation)</td>
<td>6-8</td>
<td>2,100 to 2,800 INR</td>
</tr>
</tbody>
</table>

NB: Prices based on Leh market 2011
Recommendations for Flood-prone Areas

NB: These recommendations are standard advice (source: Traité de construction en terre—CRATERRE, 2006). When a recommendation is in conflict with Indian codes, the Indian codes shall take precedence.

Main principle
Do not build in flood-prone areas.

Surroundings
Reinforce surrounding fences and encircle the house with plants if possible to break the power of the wave.

Remove heavy objects which could act as a battering ram.

Orient your house to reduce pressure of the floods’ wave on the walls.

Foundations
Build deep, solid and well anchored foundations. Foundations should be raised until the highest level of past floods in the local area.

Choose good masonry and sustainable materials. Avoid foundations made of mud and do not use non-stabilized (without cement) mud as mortar.

Walls
Add strong lintels (like cement lintels) and reinforce the masonry. Partition walls should be heavy and connected to the main walls.

Floor and roof
Reduce the weight of floor and roof as much as possible to reduce danger of debris falling in case of collapsing. Plan openings on floors and roofs to help inhabitants to escape.

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