Green Building Features for Climate Resilient Affordable Housing

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Presentation Outline

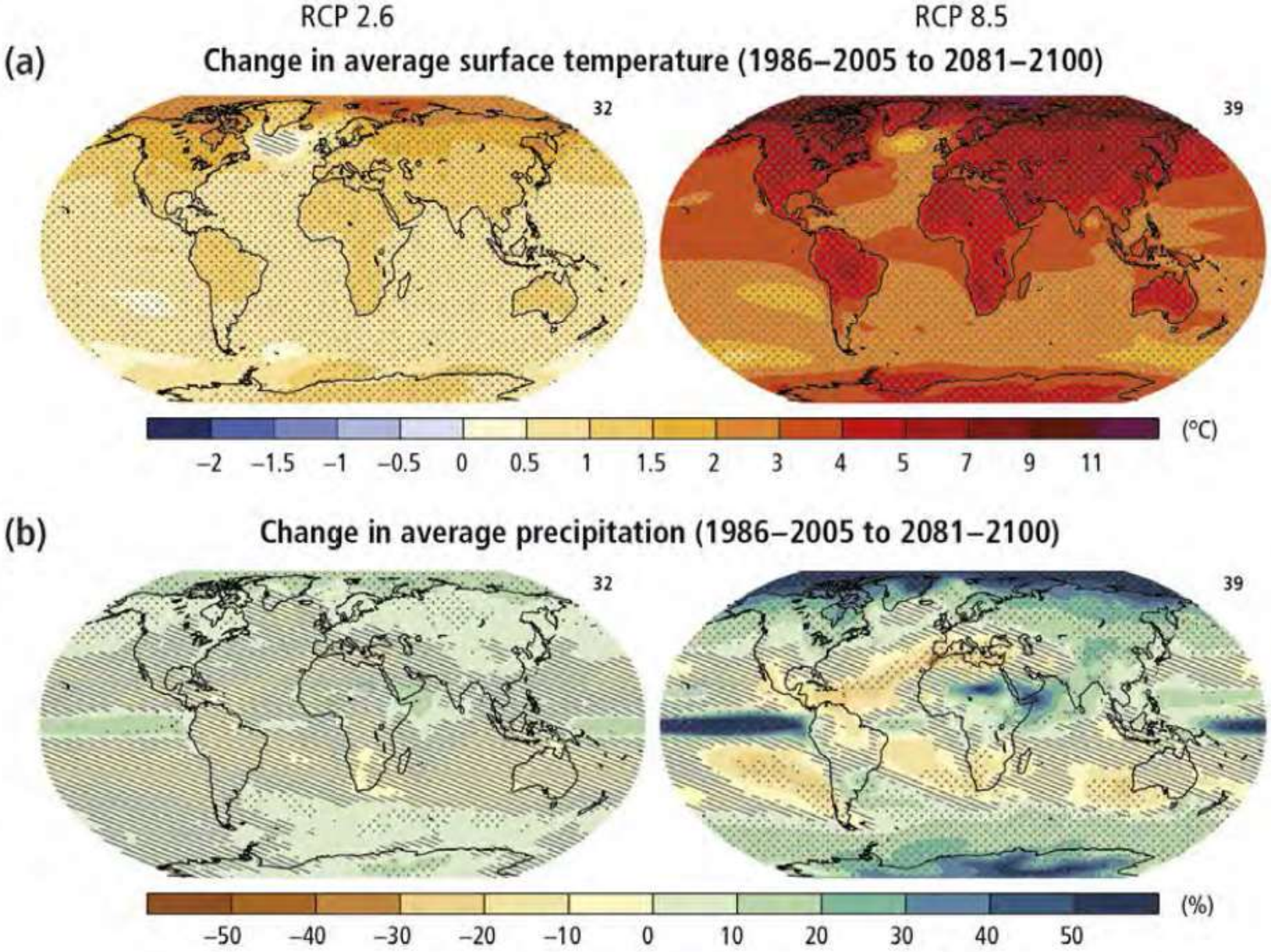
- Climate Vulnerabilities
- Climate Resilient Features for Built Environment
- Alternate Construction Technologies for Climate Resilient Housing
- Affordable Green Building features for Climate Resilient Housing
- Recommendations

IPCC Climate Change 2014 Synthesis Report

https://biocreativity.wordpress.com

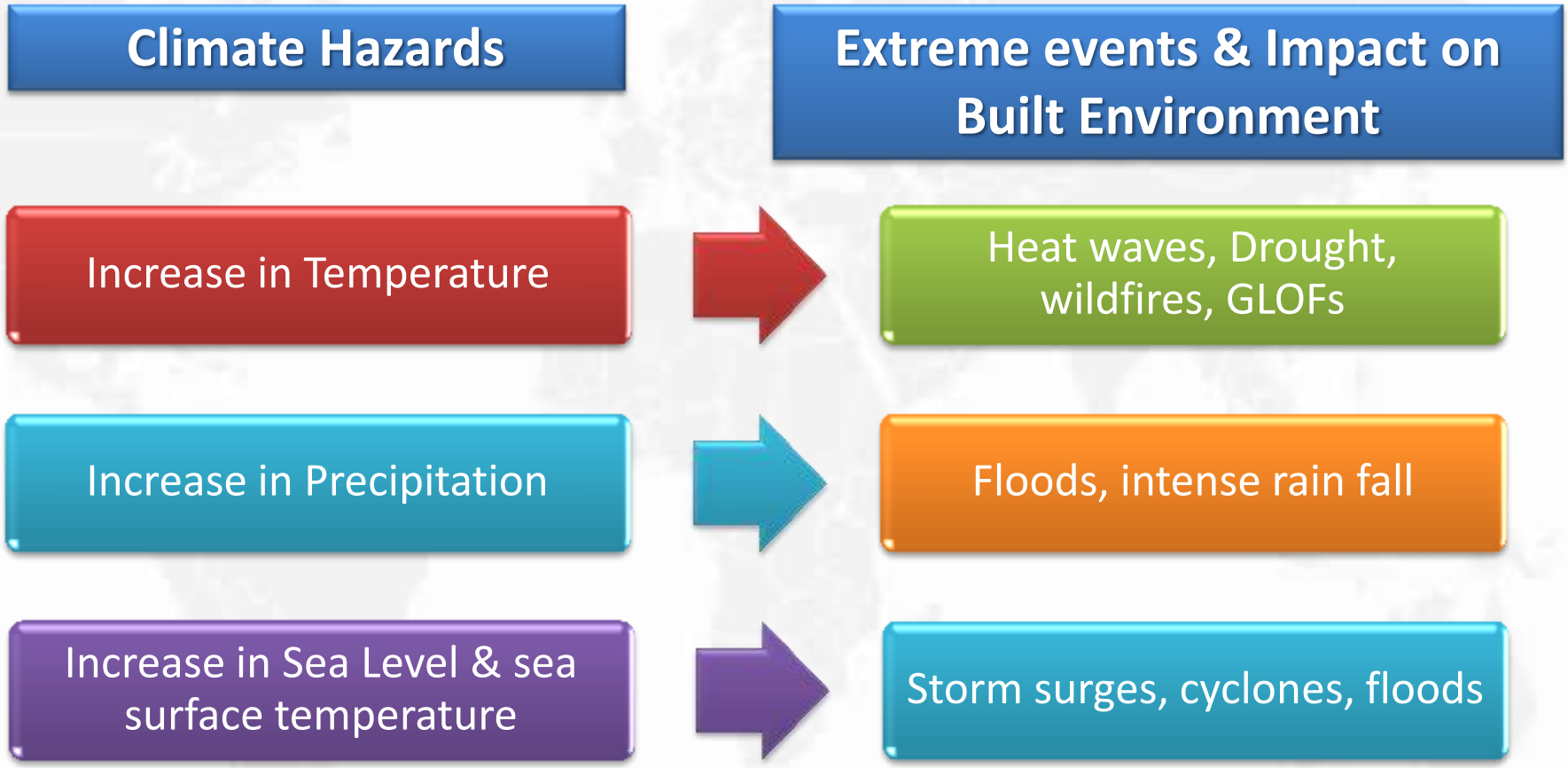
Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including :

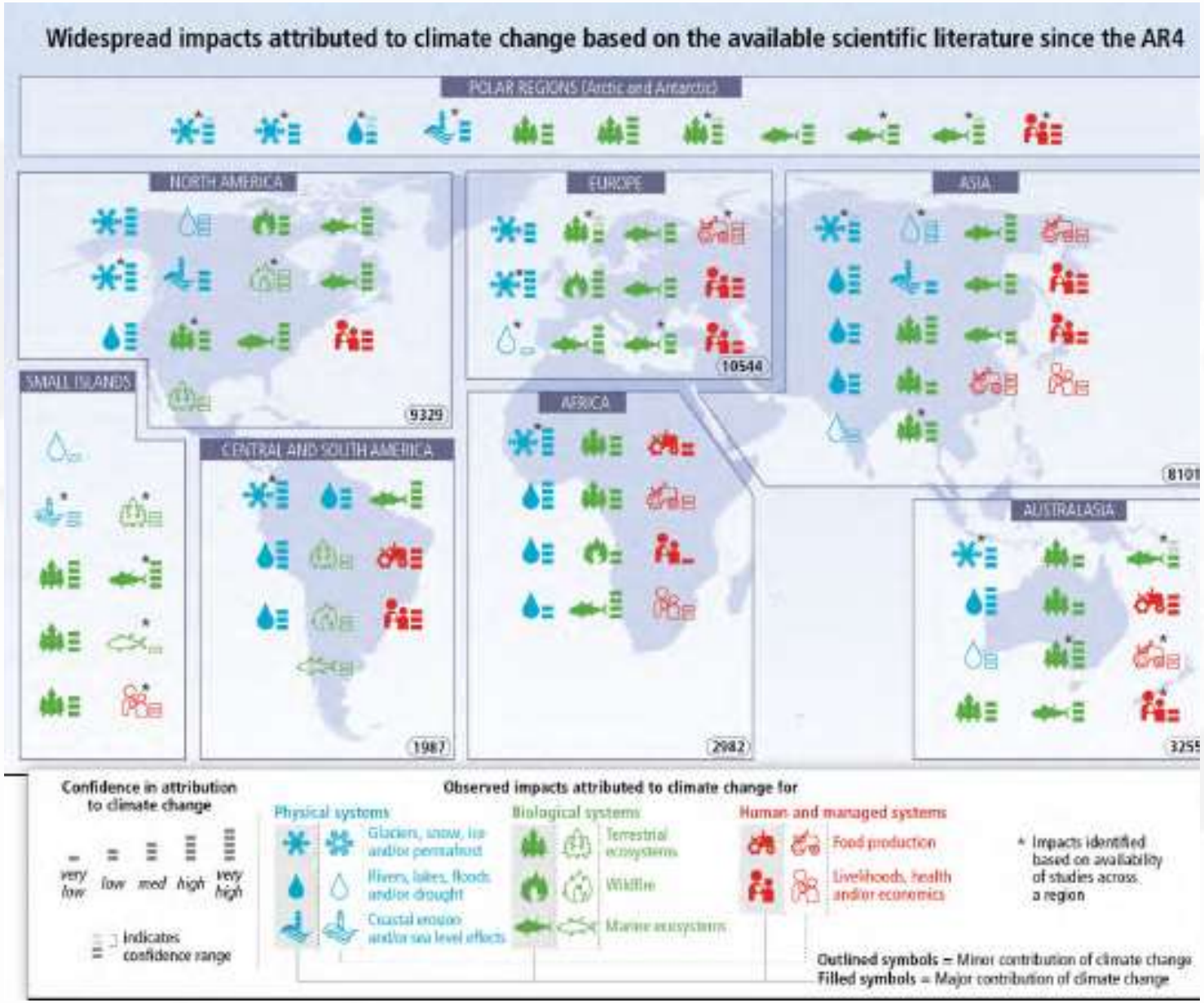
- Decrease in cold temperature extremes
- Increase in warm temperature extremes
- Increase in extreme high sea levels and
- Increase in the number of heavy precipitation events in a number of regions.



IPCC Climate Change 2014 Synthesis Report

Impact of Climate Change on Built Environment





Source: IPCC Assessment Report 5

Coastal Systems and low lying areas

Coastal systems and low-lying areas are at risk from sea-level rise, which will continue for centuries even if the global mean temperature is stabilized.

Source: IPCC 5th Assessment Report

Defining Climate Resilient Housing

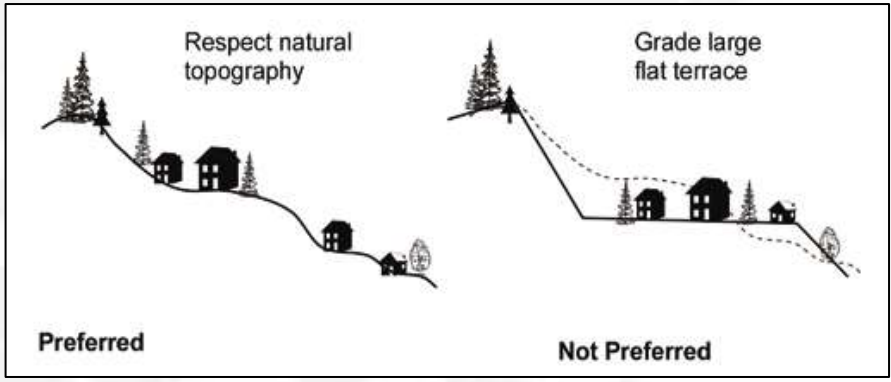
Climate Resilient Design Features make homes resilient to climate vulnerabilities, such that they maintain an acceptable level of functioning and structure.

Design Features for Climate Resilient Affordable Housing

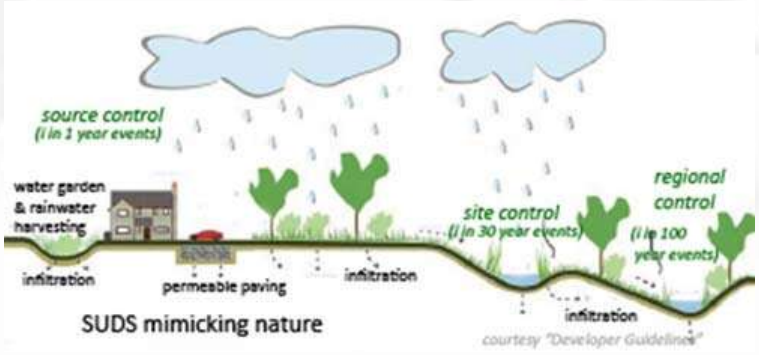
Floods, GLOFs, Landslides & Heavy Precipitation

For Settlement level

- Developments to adhere to natural site contours.
- Construction on natural drains to be avoided.
- Development to be planned in a manner to leave natural vegetation protected.
- Grading large flat terraces on hill side sites should not be allowed.
- Developments should integrate an effective storm water management system – infiltration trenches, retention ponds, downstream flood control measures.
- Reduce impervious paving
- Erosion and sedimentation control measures through swales, sedimentation pits, vegetation growth on exposed soils along with mulching.



(Source: Steep Slope Development Guidelines, City of Nanaimo)



http://sd.defra.gov.uk/2011/05/surface-water-management-and-future-water-supplies/)

Design Features for Climate Resilient Affordable Housing

Floods, GLOFs & Heavy Precipitation

Building level

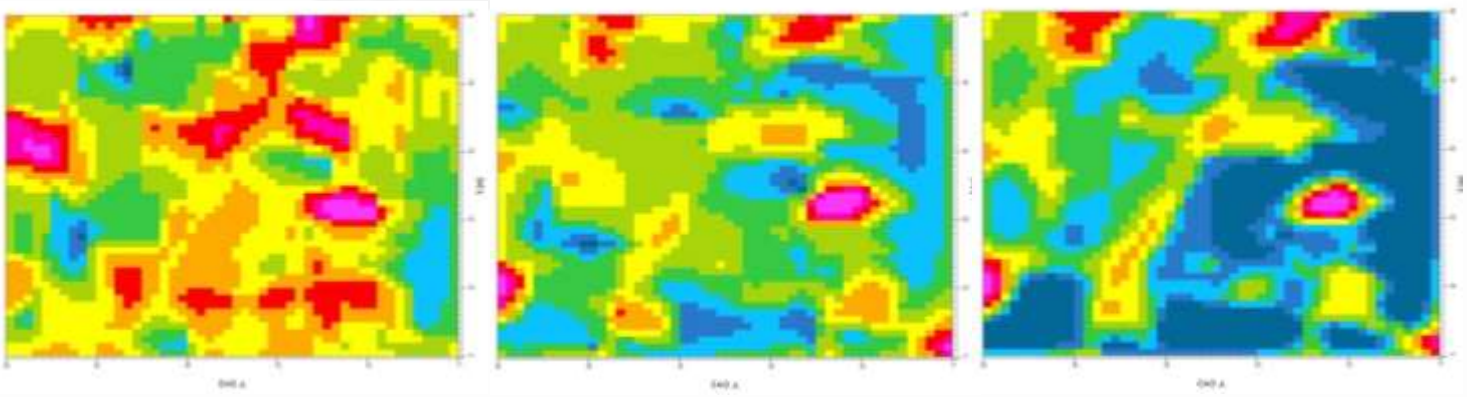
- Buildings with High Plinth.
- Raised floor level to prevent flood water entering inside the house.
- Basements for new construction should not be allowed in urban areas prone to flooding.
- Isolated RCC Foundations in hilly terrains with tie beams.
- Overhangs above openings.
- Homes to have attached toilets.
- Bitumen based damp proof course at plinth level and water proofing on roofs.

Design Features for Climate Resilient Affordable Housing

Increasing Temperatures & Heat Stress

For settlements

- In urban areas, one of the reasons for increase in temperature is urban heat island effect. Thus, reduced impervious pavements, increase in vegetation and shaded as well as light coloured building surfaces help maintain cooler microclimate.



Design Features for Climate Resilient Affordable Housing

Increasing Temperatures & Heat Stress

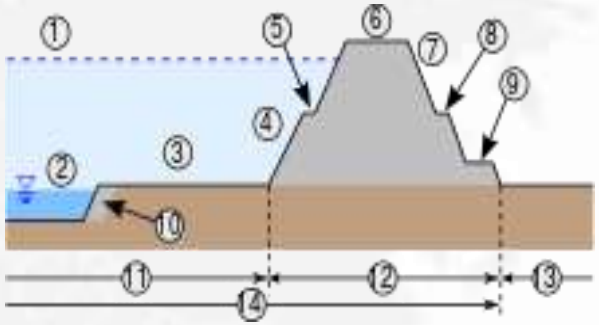
For New Construction

- Solar control strategies like shading, orientation and building morphology to reduce external heat gains and maintain comfortable indoor conditions.
- Increase in vegetation around the house.
- Increase in ventilation through optimization of window design and size.
- Cool roof/Roof Garden
- Use of thermal storage through building materials like local stone and stabilized earth blocks.

Design Features for Climate Resilient Affordable Housing

Cyclones, Floods & Storm Surges in Low lying coastal areas

- Deep Foundations – Pile foundations for Large buildings and RCC Strip foundation for homes
- Buildings with High Plinth, preferably 6” above highest flood level mark.
- Raised floor level to prevent flood water entering inside the house. Building on stilts.
- Basements for new construction should not be allowed in urban areas prone to flooding.
- Anchoring between building components.
- In low lying coastal areas, developments should be considered on higher grounds, or ground should be raised artificially.
- Construction of embankments or dykes is key for low lying settlements near coastal areas.

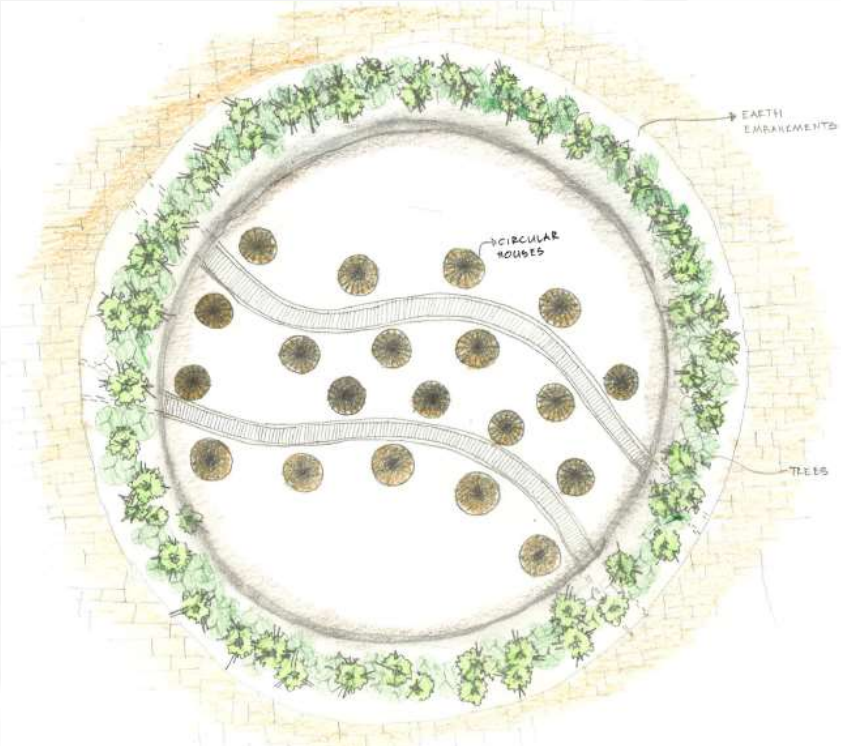


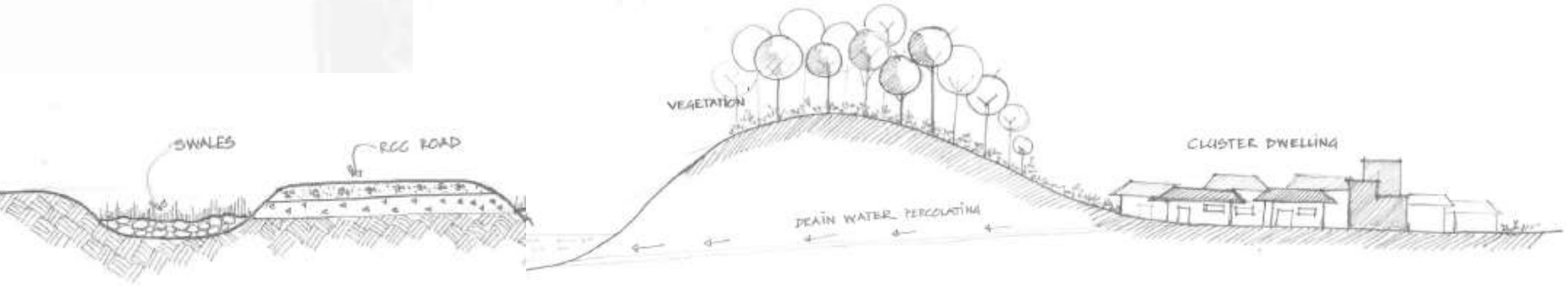
http://en.wikipedia.org/wiki/Levee

Design Features for Climate Resilient Affordable Housing

Cyclones, Floods & Storm Surges in Low lying coastal areas

- If higher grounds are not available, then settlements should be constructed on artificially raised grounds.
- Tree plantation to protect from cyclonic winds.
- Adopt a non regular layout in place of straight rows to prevent tunnel effect during cyclones.
- Square, hexagonal and round plan is safer than long rectangular plan.
- Pyramid shape roof is ideally suited.





Retrofit of Existing Housing to add climate resilience

Floods & Heavy precipitation

- Water proofing on roof and plinth level (Grouting)
- Water proofing on walls
- Protecting openings with overhangs
- Storm water Drainage systems

Increase in temperature and Heat Stress

- External insulation on the roof

Cyclone, storm surges

- Replacement of GI sheets in roof with composite boards anchored with the structure.
- Strengthening plinth and then caping with concrete.
- Tiling of walls for salinity resistance

Alternate Technologies to make Climate Resilient Homes Affordable

Increase in construction cost after adding climate resilient features is 10-12%.

Alternate/Affordable Construction features for Multi residential Developer made Homes

Building Component	Conventional Practice	Alternative/ Affordable Construction	Cost Reduction (in %)
Foundation	Brick foundation	R C C Strip foundation	37
Wall	Brick wall	Cavity wall	20
Roofing	R C C Slab	Filler slab	22-25
Opening frames	Teak/ Hard wood Door/ Window frames	Pre cast RCC frames for Door/ Window	30

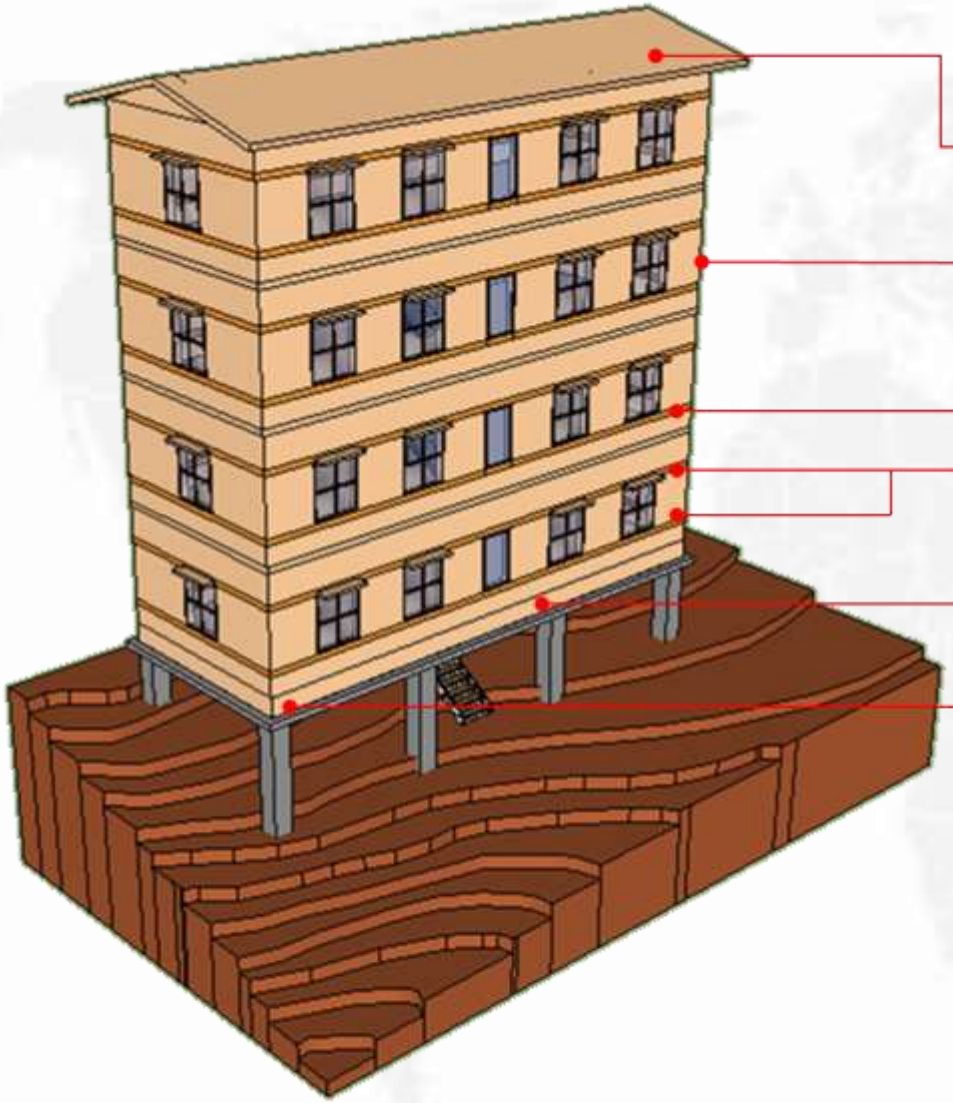
Reference: Low cost Housing by Bhubaneswar LalShresta, 2007; Alternative building materials and technology Dissemination by Suresh V, 2002.

Alternate Technologies to make Climate Resilient Homes Affordable

Alternative/ Affordable construction features for self construction in rural locations

Building Component	Conventional Practice	Alternative/ Affordable Construction	Cost Reduction (in %)
Foundation	Brick work	Stone masonry	60-70%
Wall	Brick work	Hollow concrete block, Adobe	50%
Flooring	PCC	Stone Tile/ Brick tile Soling	30-40%
Roofing	C. G. I Sheets on Iron pipes	C. G. I Sheets on Bamboo	40%
Openings	Wooden Frames (Teak Wood)	Aluminium Frames	33%

House Design proposed for Multiple Hazard Locations



RCC Gable roof ⑥,
Damp proof course (DPC) ⑥

Hollow Concrete Block Masonry ④ ⑤

Ring beam at Sill level and Lintel level
② ⑦

Bitumen based DPC ① ③

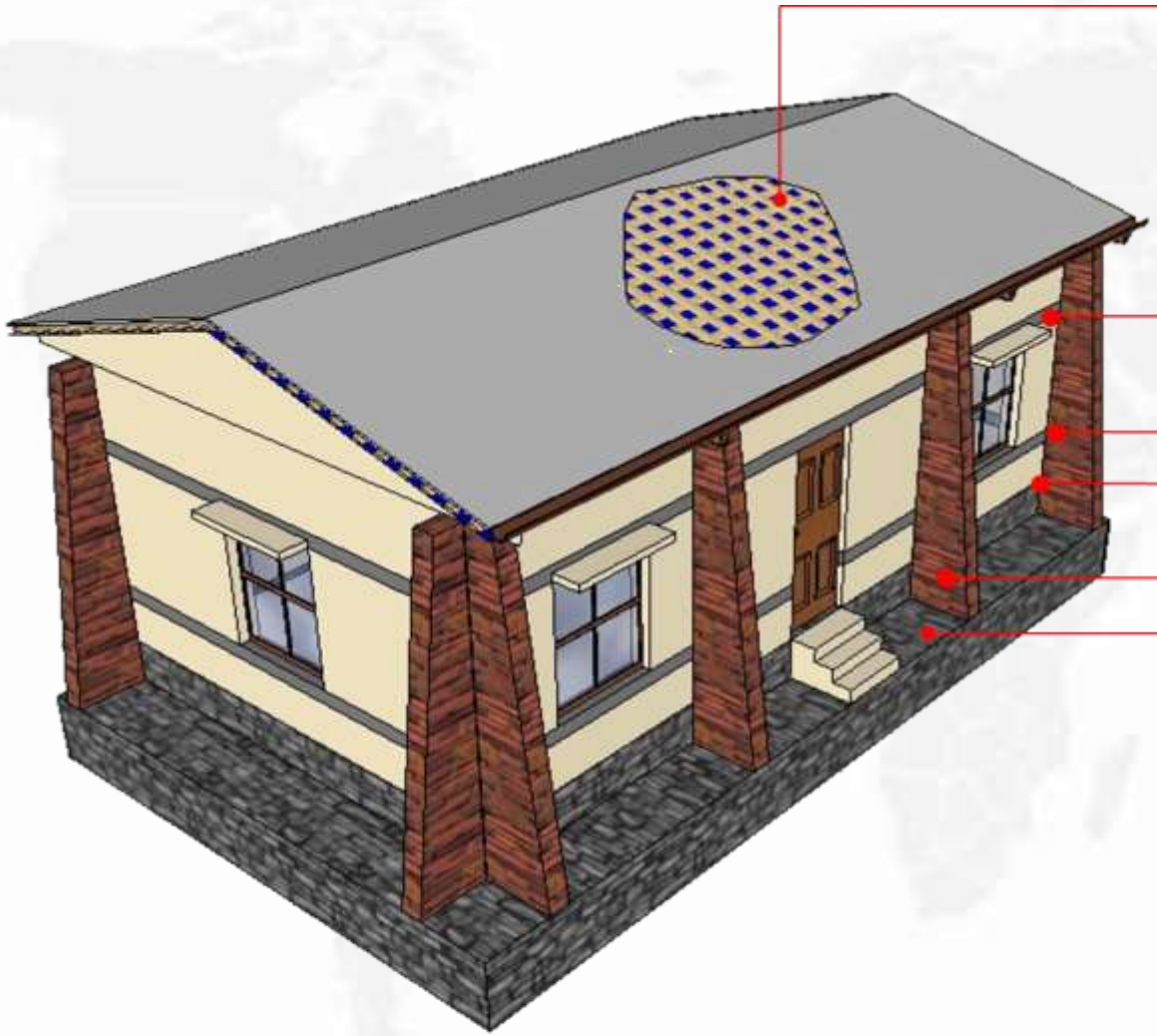
Raised floor ① ③

①	GLOFs
②	Landslides
③	Floods
④	Heat stress
⑤	Extreme cold
⑥	Heavy Rains
⑦*	Earthquake

Note: *Structure of the house to comply with the earthquake resistant design specifications provided in NBC

Proposed for Developer build Multi- Storey Climate resilient Home

House Design proposed for Multiple Hazard Locations



Ferro-cement roofing on bamboo supporting structure ⑥

Lintel & Sill beams with Bamboo Reinforcement ②⑦

Bitumen based DPC above Plinth Beam ③⑥

Buttress ②⑦

R C Strip foundation ①②⑦

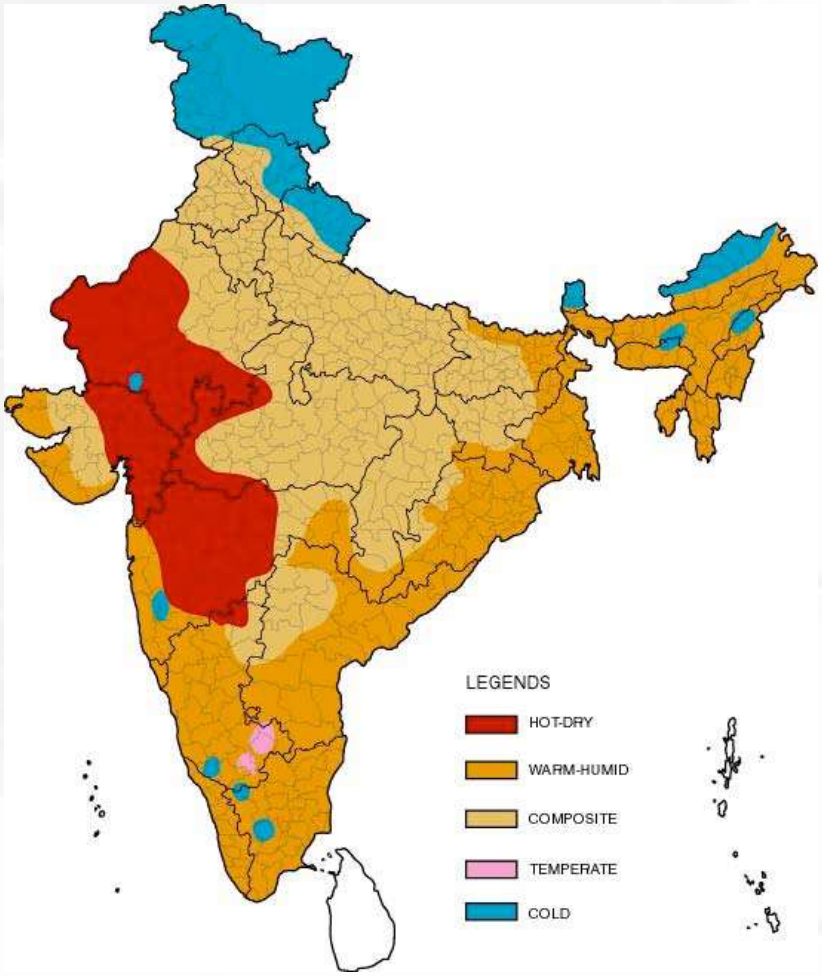
①	GLOFs
②	Landslides
③	Floods
④	Heat stress
⑤	Extreme cold
⑥	Heavy Rains
⑦*	Earthquake

*Note: Structure of the house to comply with the earthquake resistant design specifications provided in NBC

Proposed for Self construction Climate resilient Home

Green Features that are Affordable for Integration in Housing projects

- Mapping of green homes
- Mapping of green and affordable homes
- Mapping of affordable green features in projects – both a habitat level and individual house scale.



Prepared by HUDCO & TERI for MoHUPA, GoI

Green Features Integrated in the Project

Site Level:

- Rainwater Harvesting
- Water Treatment &Reuse
- Waste Segregation &Treatment
- Preservation of existing resources– Existing Trees, Contours, Top Soil Preservation
- Landscaping – Native Species, Pervious Pavement
- Low Embodied Energy & Local Materials Usage
- Renewable Energy Based Outdoor Lighting

Building Level:

- Passive Designing - Natural Lighting, Ventilation
- Climate Responsive Building design and envelope
- Solar Water Heating
- Efficient Water Fixtures
- Low Embodied Energy and usage of local materials
- Efficient Lighting

Preservation of existing resources– Tree & Top Soil Preservation

Parameters	In case study	Conventional Practice
Usage	During and after construction existing trees and top soil are preserved and protected.	Cutting existing vegetation; purchase, transportation and filling of top soil involved
Green Rationale:	Preserve eco system ,improves micro climatic conditions, Minimizes soil erosion & manage storm water drainage	Degrades the environment
Cost incurred	- Cost for top soil preservation: Rs 17/Cu.m - Cost for Tree protection: 0	Cost for purchase of top soil, processing : Rs 228/Cu.m
Affordability & Replicability	**Preservation of existing Tree & Top Soil is affordable and replicable because its cheaper than conventional practice**	

Pervious Pavement

Parameters	In case study	Conventional Practice
Usage	87% of site area is softscaped using natural stones , mud concrete & VDF concrete across the site.	Majorly designed with impervious area
Green Rationale:	Controls Heat Island effect & Storm water runoff, controls storm water through percolation of water & recharging ground water.	Surge in heat island and disruption in ground water recharge due to impervious paving.
Cost incurred	Rs 295/sq.m for laying pervious paving using natural stones and grass	Rs 350/sq.m for laying complete impervious paving
Affordability & Replicability	**Pervious paving is affordable and replicable by using tiles and stones left from homes and run-off used to recharge ground water table as its cheaper than conventional practice**	

Pervious Paving for Vehicular Movement

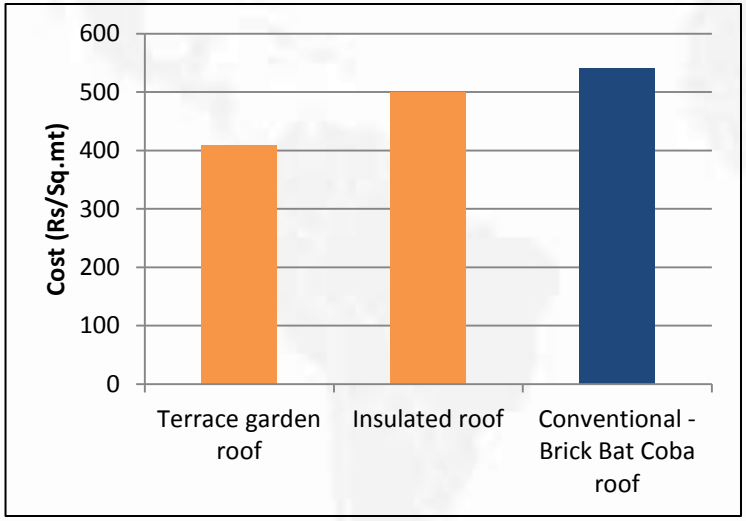
Parameters	In case study	Conventional Practice
Usage	Water percolation and parking	• Cement, Asphalt for parking • Interlocking Concrete blocks for percolation
Green Rationale:	Reduces Heat Island Effect and evaporation, helps in rainwater percolation and recharge	Water flooding, wastage due to evaporation, Heat island effect
Cost incurred	Rs 350 Sq.mt	Interlocking blocks – Rs 400/Sq.mt PCC – Rs 420/Sq.mt
Affordability & Replicability	**Affordable than a conventional method**	

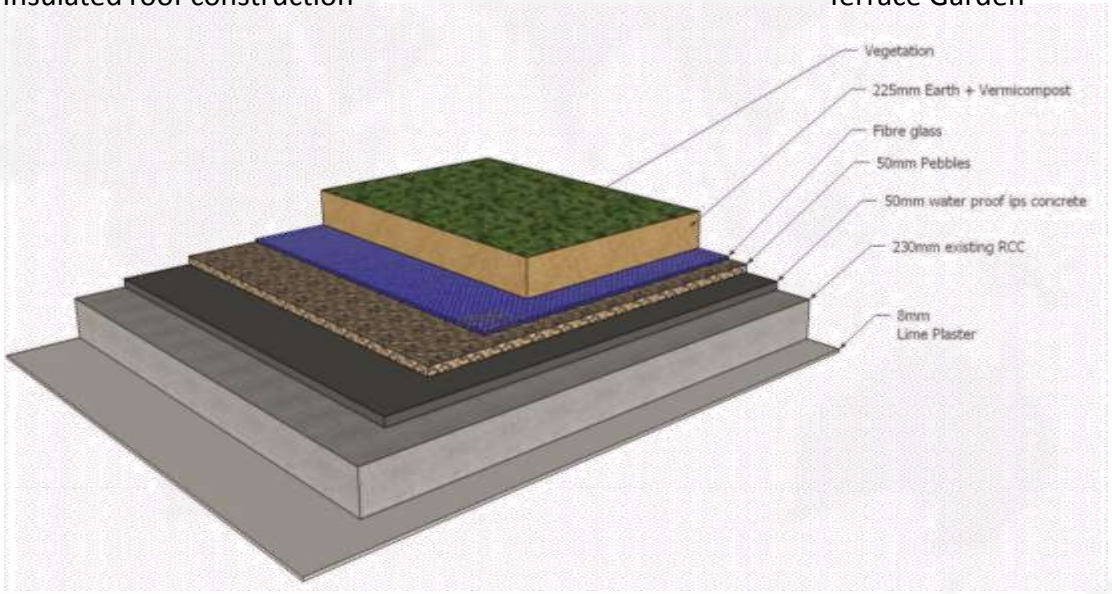
Green Roof

Brick Waste

Insulated roof construction

Terrace Garden





Terrace Garden Roof:

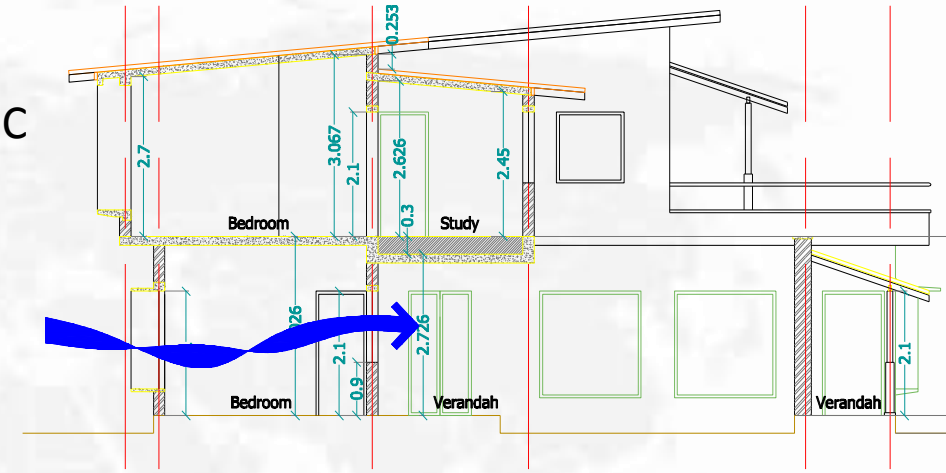
Earth + vermin compost + fiberglass mesh + cement + sand + grit + water proofing + RCC

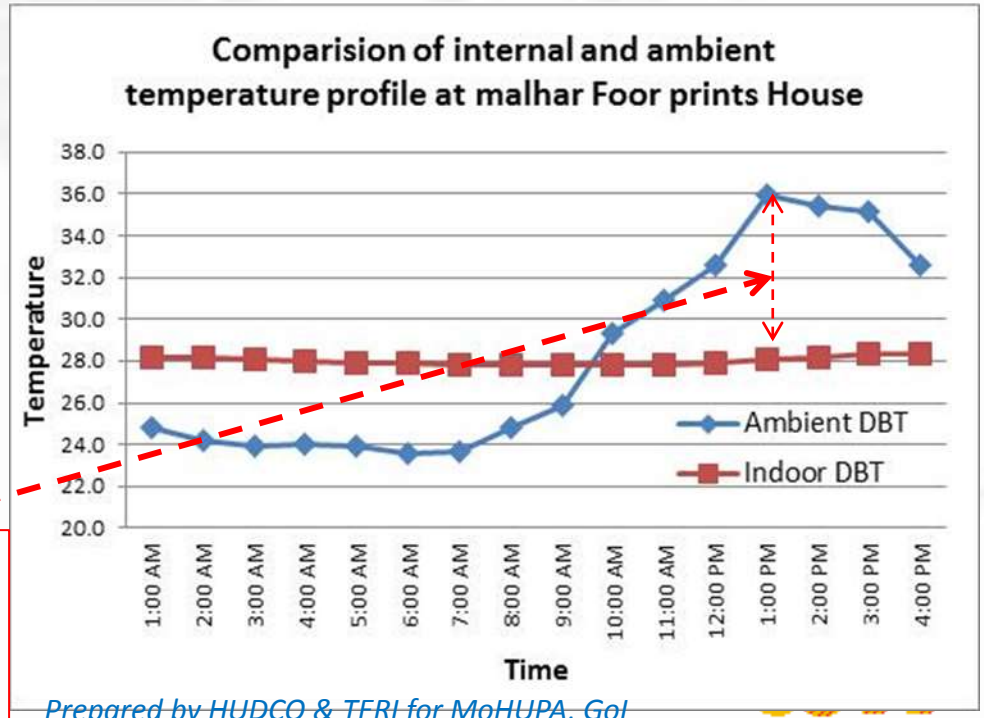
Insulated Roof:

Waste brick + lime + sand + Waste Thermocol + RCC

Passive Design Features – Natural Ventilation

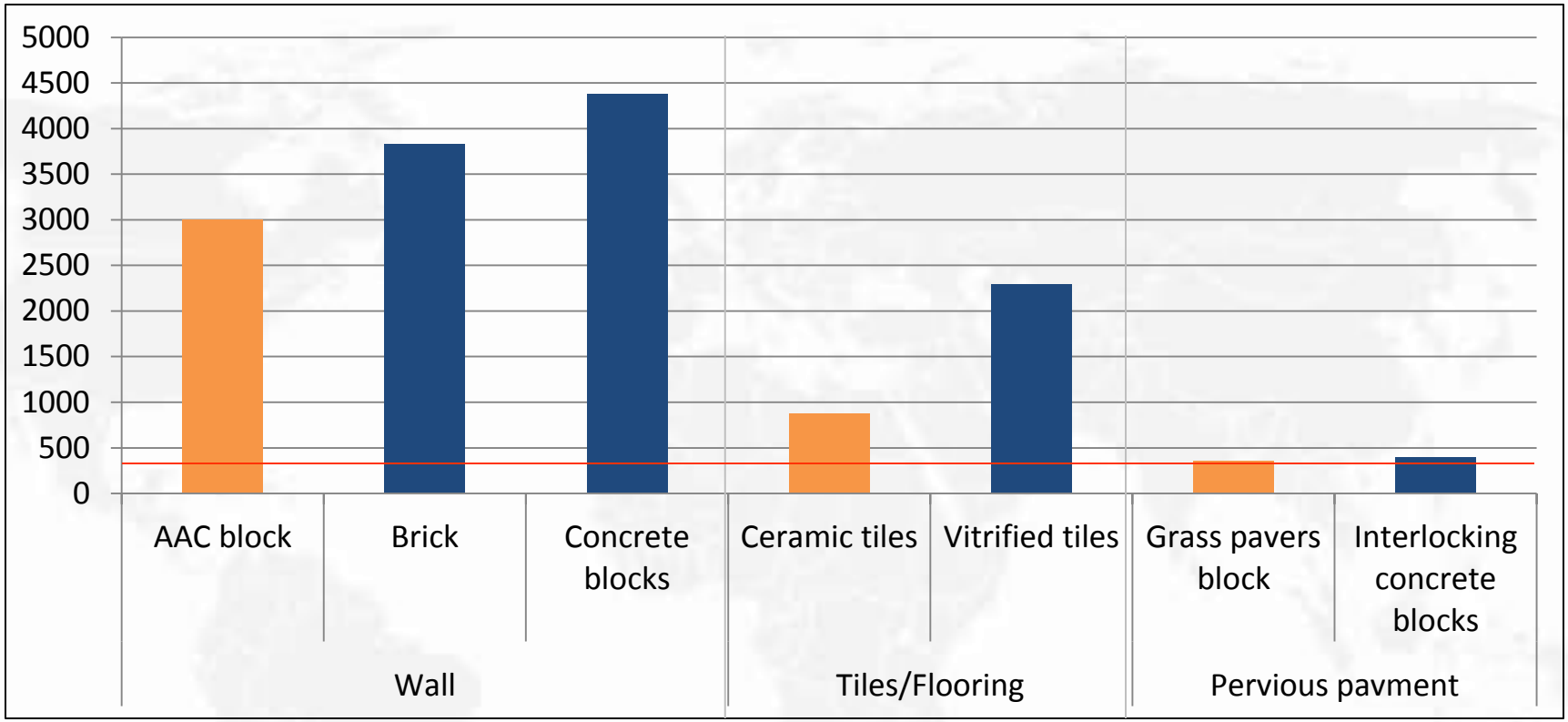
- Cross ventilation observed
- Thermal comfort measured acceptable by NBC





7 deg C temperature difference

Alternative Materials – Green + Low Cost



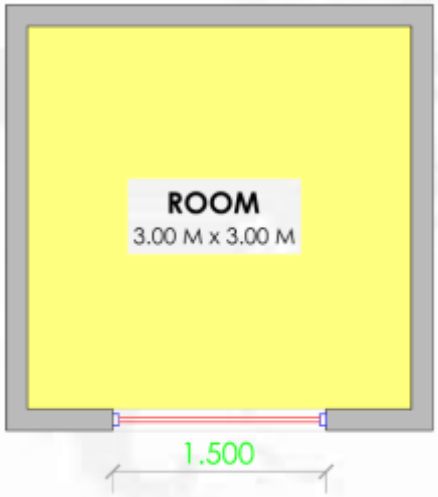
AAC Blocks:

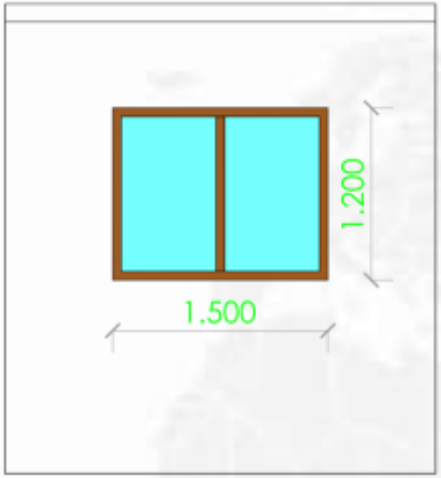
- Improved thermal efficiency
- Fire resistant
- Minimizes the generation of solid waste during use
- Less embodied energy
- Light weight & thereby saves cost & energy in transportation & labor

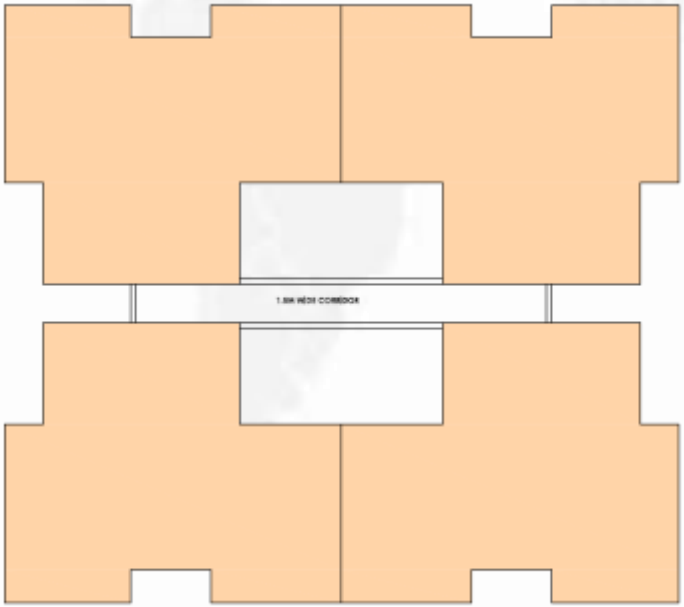
Ceramic Tiles:

Low embodied energy

Key Affordable Features- Efficient Space Utilisation & Standardisation







- **Window Area**- Optimized, more than bye law requirement; reduces the load on artificial light, enhances ventilation
- **Minimum & Standard Room Sizes**- reduces material wastage & real estate cost
- **Minimum Corridor width**-reduces material wastage & real estate cost

Key Affordable Features- Alternative Materials, Construction Techniques


R C Wall- No Plaster


Staircase


Pre cast Compound Wall- Minimal Foundation, fast construction

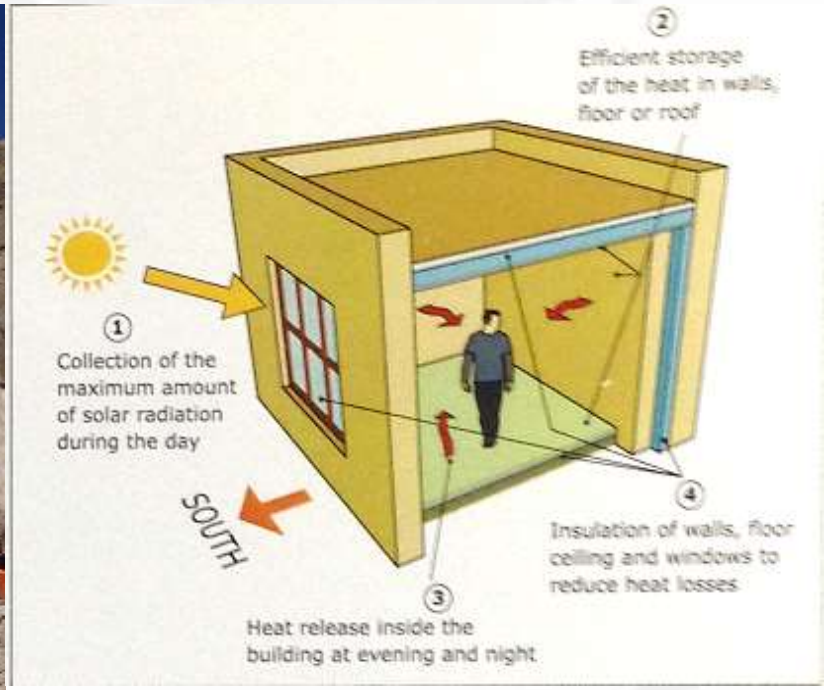

Window grill


Kitchen Platform- Simple fixing, Minimal material usage

Passive Solar House Design in Cold Climate Zones

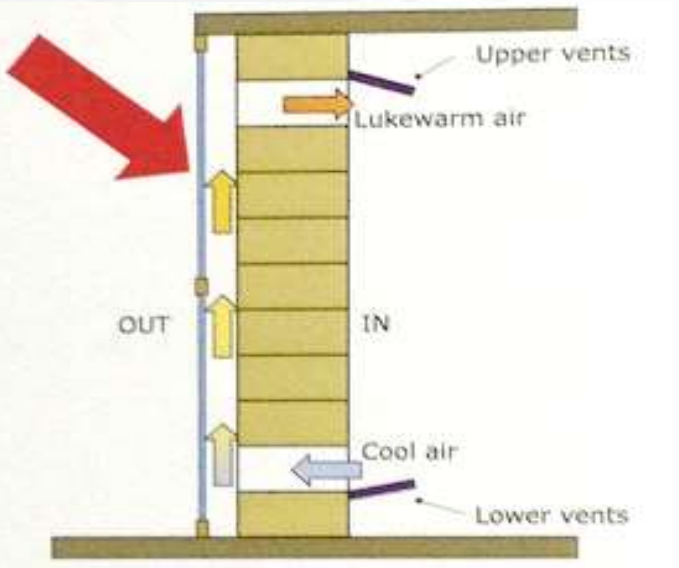
Direct gain (DG)

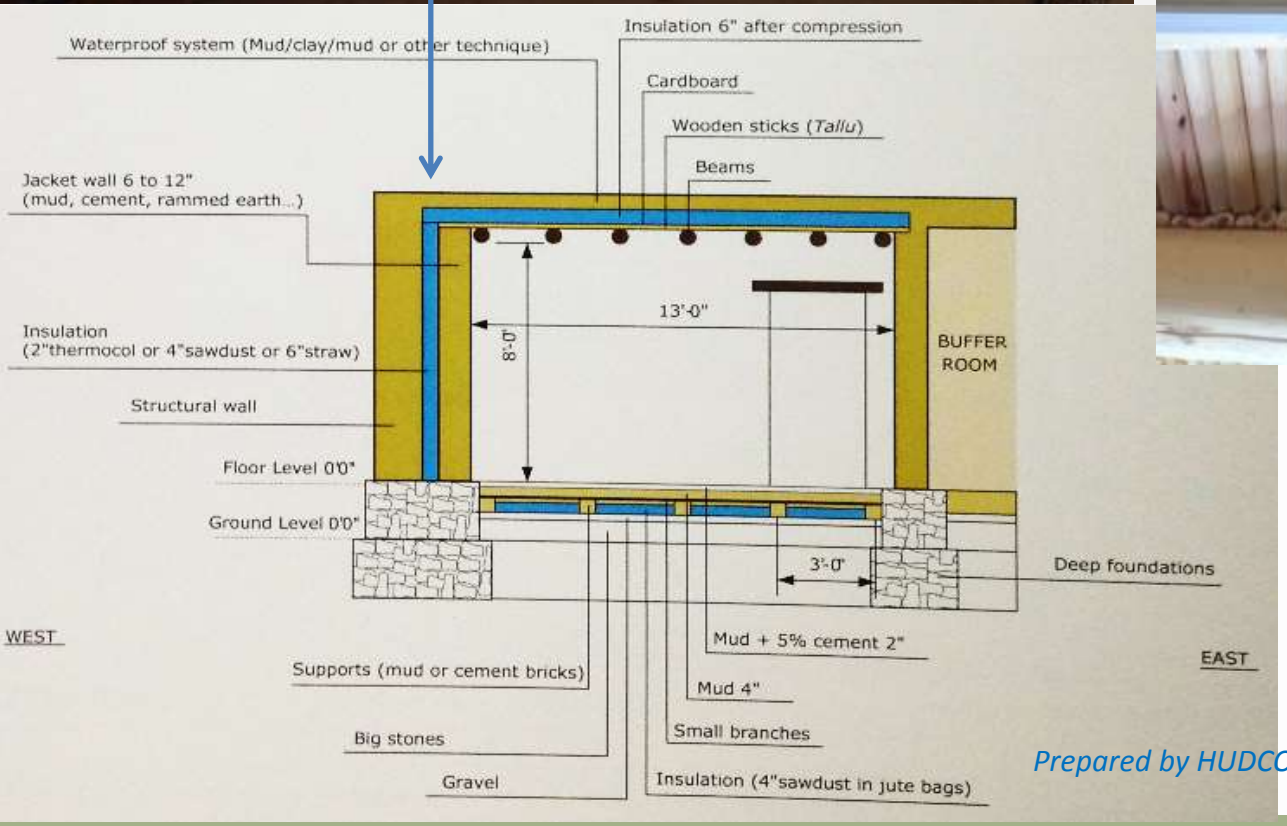
Construction cost = INR 958/m2 of wall area



Solar Wall (SW)

Construction cost = INR 1596/m2 of wall area



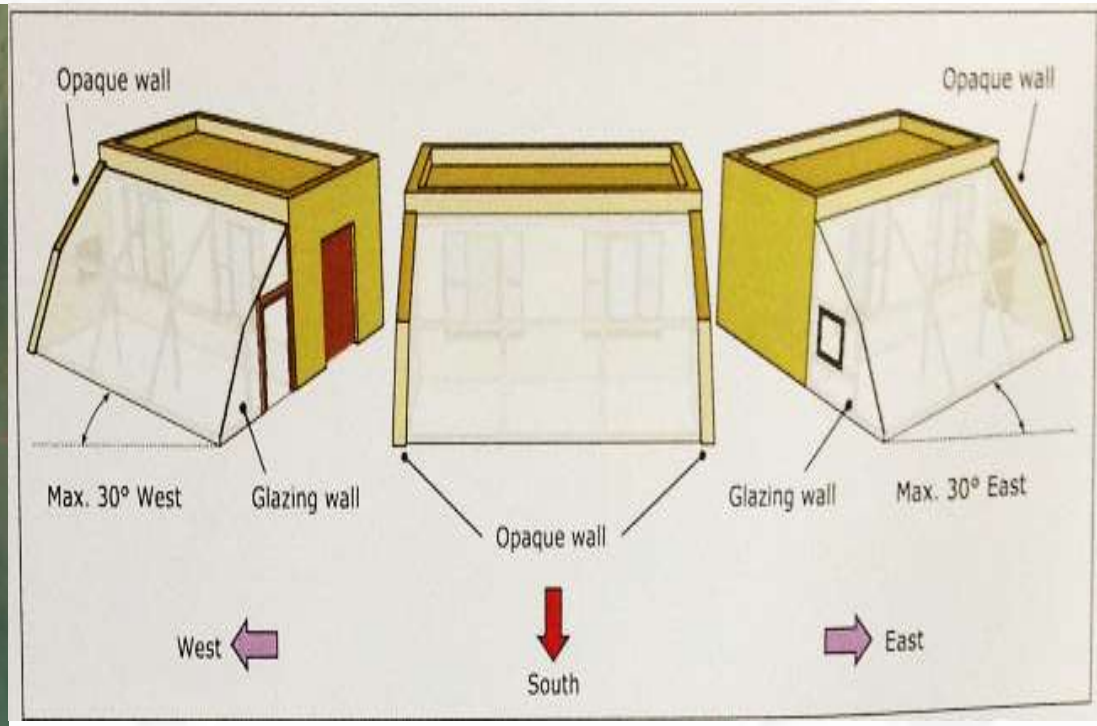


Energy efficient CFL tubes

Prepared by HUDCO & TERI for MoHUPA, GoI

Attached Green House

Construction cost = INR 1277/m2 of wall area



Local low energy materials

- Sun dried mud bricks
- Yakzes
- Saw dust
- Wood
- Markalak clay

On site monitoring

Parameters	DG	SW	AGH
Inside temperature (°C)	23.4	19.9	21.1
Inside lux (Middle of room)	350	210	160
Outside temperature(°C)	17.9	17.9	17.9
Relative Humidity (%) inside	26	20	20

Water Efficiency in Building water demand

Parameters	In case study	Conventional Practice
Usage	Low flow water fixtures in toilets & kitchen	High flow fixtures
Green Rationale:	Highly efficient & reduced demand with dual flush 3/6 lts/flush water close	Less efficient & higher water demand with single flush water closet of 15 lts/flush
Cost incurred	Rs 6500/unit	Rs 5000/unit
Affordability & Replicability	*Efficient water closet* **is affordable and replicable as its pack back is less than 1 year in comparison to conventional practice**	

Water Efficiency in Building water demand

Life cycle cost analysis

Parameters - water management	Water Closet with 3/6 litre/flush dual flush	Conventional Water Closet of 14 litre/flush
Cost/unit (Rs.)	6500	5000
Cost comparison (%)	23% higher	-
Annual Water consumption for 4 member family (litres)	19710	78840
Annual water consumption (%)	75% lower	-
Water saving through tankers supply		
Water tanker capacity for each supply (litres)	6000 litres	
Cost of each tanker (Rs.)	Rs. 750/-	
Total tanker required to meet the annual water demand	3	13
Annual total cost of supplying water through tanker (Rs.)	2250/-	9750/-
Annual cost paid for tanker	75% lower	-
Water required annually through tanker	75% lower	-

Life Cycle Cost Analysis for Waste Water Treatment System & rain Water Harvesting in Housing Projects

Details	Litres	kilolitres	
total water demand (litres)	87000	87	daily
total water demand (litres)	31755000	31755	yearly
water from rain (litres)	5300000	5300	yearly
water from recycled water(litres)	21000000	21000	yearly
water from ground water (litres)	12700000	12700	yearly
each water tanker supply (litres)	6000	6	each tank
Cost of each tanker (Rupees) in bulk supply	500		Rs/tanker
Initial investment cost of each component for water supply such as rainwater harvesting, DEWATS system, ground water installation was taken into account.			
Cost of each component		**cost (Rupees)**	**In million rupees**
Installation cost of Rain water harvesting		4100000	4.1
Installation cost of DEWATS		2900000	2.9
Installation cost of ground water installation with break up below		180000	0.18
bore well drilling cost with casing		40000	0.04
Pump and electrical cable		120000	0.12
electrical panel and wiring		20000	0.02
total cost initial investment- (A) (Rupees)		7180000	7.18

Maintenance cost of each of the above components, for ten years, were taken into consideration as depicted below:

maintenance cost for 10 years	cost (Rupees)	Period	Cost for Ten Years Rupees)	In Million Rupees
cost of Rain water harvesting	1200	per annum	12000	0.12
cost of DEWATS	66000	Per annum	6,60,000	0.66
electrical Consumption/day of	22000	per month	2640000	2.64
ground water installation maintenance cost per year	10000	Per annum	100000	0.1
total maintenance cost (B)			2752000	2.752
Grand total A + B			Rs. 10592000	**10.592**

Cost of water supply through water tankers

Details	quantity	units	In Million Rupees
Each water tanker capacity	6000	each tank	
Cost of each tanker	500	Rs/tanker	
No. of tankers required	5293	per year	
Total cost (Rupees)	2646250	per year	
Total Cost for 10 years (Rupees)	Rs. 26462500		**26.4625**

The water management system with rainwater harvesting, DEWATS system, ground water installation saves up to 60% as against water supplied through tanker for a period of 10 years.

Renewable Energy Based Outdoor Lighting

	Stand-alone SPV-LED	Sodium Vapour
Lamp Cost (Rs)	2,500	1,750
Battery Cost (Rs)	6,000	0
SPV Cost (Rs)	4,000	0
Pole (Rs)	4,000	4,000
Wiring & Installation (Rs)	3,500	2,500
Total Cost (Rs)	20,000	8,250
Wattage (W)	14	150
Consumption in kWh (for 3 Years)	184	1971
Tarrif (Rs)	0	6
Total Operational Cost (Rs)	0	11826
Total Cost (Rs)	20,000	20,076
Payback	3 years	

Solar Based Hot Water Systems

Green Rationale: Reduces energy usage from grid and thereby natural fossils fuels

Cost Factor: Initial investment shall be high. Lifecycle cost shall be far lower

Total installation capacity = 2000 litres
Cost of installation = 4 lakhs rupees
Payback is 2 years approx.

The above cases are either Demonstration projects or voluntary projects. Usually in India and many developing countries Rehabilitation work is carried out after the climate hazard stuck. Example in October, 2014, Hud-Hud Cyclone on the coast of Andhra Pradesh affected 0.250Million people and 60,000 families, damaging 2250Kms of Road infrastructure…

Can we have Climate Resilient Infrastructure and Built Environment?

Barrier Analysis

- Missing policies to make climate resilient housing in climate vulnerable locations.
- Missing policies to make affordable homes green.
- Low Awareness on green initiatives and climate resilient features that need to be integrated in affordable housing.
- Missing Financial policies and incentives to promote Green and climate resilient housing in the climate vulnerable locations in India.
- No or limited incentives for borrowers from Government or financial institutions, for those, who are building green & climate resilient homes.
- Green building features & climate resilient features are not yet integrated in the Schedule of Rates developed by most of the States.

Pilot Program for Climate

World Bank Group [US] https://www.climateinvestmentfunds.org/cif/node/4

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Pilot Program for Climate Resilience

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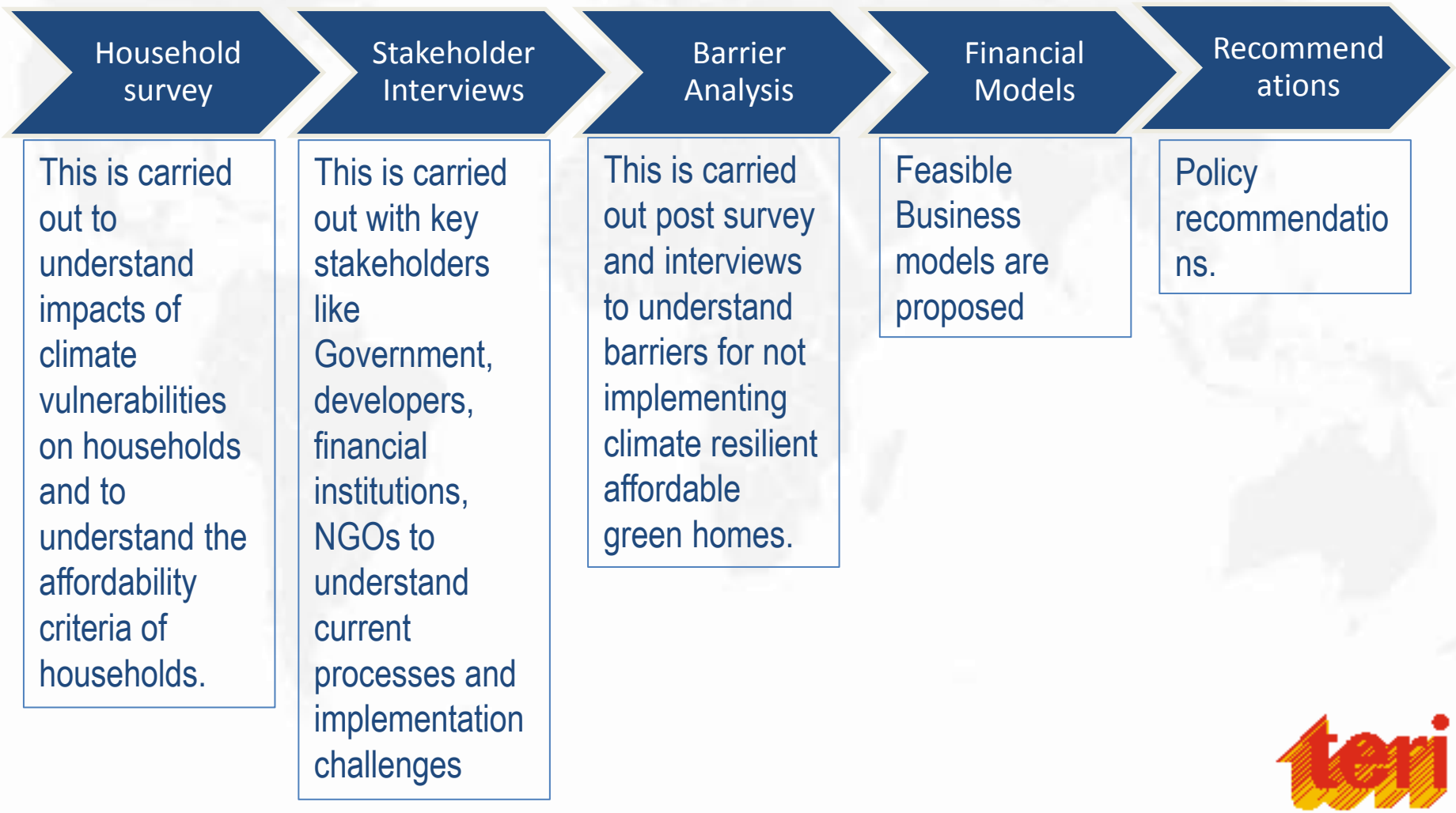
Objective

1. To assess the market potential for climate resilient low cost housing
2. To design a feasible business model including developing a low cost housing insurance framework and identification of potential implementing partners for pilot interventions

Methodology/ Approach



Policy Recommendations

1. Policies by Government to mainstream green and climate resilient affordable homes.
2. Policies for Financial Institutions to lend to climate resilient green affordable homes.
3. Integration of green features and climate resilient features in Schedule of Rates and Building Bye – Laws.

Thank You

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