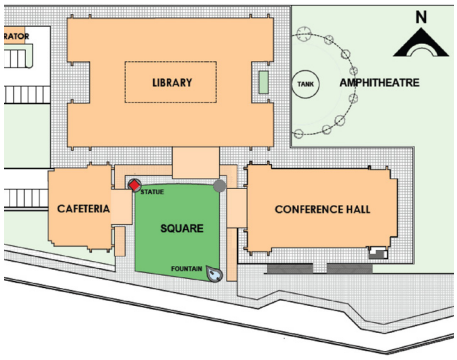
10

Urban Energy Technical Note

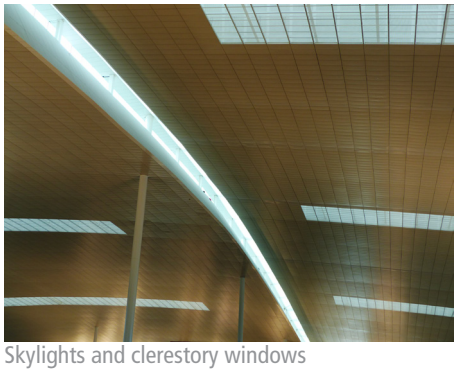
Key Strategies for Sustainable Building Design in the Tropics

	STRATEGY
1	**Site selection** • Use of existing buildings - to reduce energy required for new buildings • Brownfield sites preferred over undeveloped green field sites • Special consideration for disaster prone areas (floods, landslides etc.)
2	**Building footprint** • Should conform to the permitted site coverage • The remaining area should be permeable to ensure rainwater infiltration
3	**Building orientation** • Buildings should be designed so that the long axis is along the east - west axis.
4	**Building form / shape** • Buildings that are narrow in plan help to achieve maximum natural light penetration, good cross ventilation and minimal heat gain.
5	**Allocation of spaces within the building** • Location of building services - toilets, staircases, lifts, lobbies, stores, ducts etc. - on the east and west facing walls to act as buffer zones against heat gain.
6	**Openings** Window sizing (according to the prevailing climatic conditions) • Window to Wall Ratio (WWR) of 0.2 - 0.3 is acceptable • Hot and humid - to allow for maximum air movement large openings are recommended - at least 50% of north and south facing walls and glazing should not exceed 20% of the wall area • Hot arid and hot semi-arid/ savannah - 10-20% of the area of north and south facing walls should be operable • Lakes region - openings should be 25-40% of the area of north and south facing walls. The glazed part of the openings should not exceed 15-20% of the whole • Upland / High upland - north and south facing windows should be large to allow for passive heating. 15-25% of the wall area should be operable Window placement • They should be placed in the north and south facing walls for easier sun control • They should be avoided in the east and west facing walls - it is difficult to control shading
7	**Day lighting** • Openings should be provided in the north and south facing walls • Narrow plans should be used to aid in day light penetration into the building • Clerestory windows, atriums, solar tubes, mirror ducts etc. can be used to enhance natural day lighting • Light shelves can be used to redirect daylight and control glare • Staircases, toilets and kitchens should always be provided with day lighting



Building orientation of The Learning Resource Center © Musau Kimeu

Orientation along east-west axis. Local building materials © UN-Habitat / Marja Edelman



Skylights and clerestory windows © UN-Habitat / Zeltia Blanco

STRATEGY

8 Sun shading / Solar control

- Design appropriate shading devices for glazed surfaces using sun shading devices - roof overhangs, vertical and horizontal sun-shading elements, balconies, screens, vegetation etc.
  - Horizontal shading devices are appropriate for north and south facing facades
  - Vertical shading devices are appropriate for east and west facing facades
  - Egg-crate shading devices are appropriate for south west, north west, south east and north east facing facades

9 Ventilation and cooling

Passive

- Use of operable windows, thermal chimneys, roof vents, louvered fenestrations etc.
- Use of passive ventilation strategies for natural ventilation – cross ventilation, stack effect, solar chimneys, clerestory windows etc.
- Provision of openings and manual operable windows in all habitable spaces
- Use of narrow plans to allow for cross ventilation
- Use of passive cooling strategies – evaporative cooling, vegetation, wind turbines, rock bed heat exchanger, ground cooling, green roofs etc.

Active

- In the case of artificial cooling make provision for proper insulating material to avoid additional heat gain

10 Heating

Passive

- Suitable for upland / high upland climates
- Medium weight walls, floors and ceilings are recommended for the best exploitation of passive solar gains
- Design should allow for penetration of sun into the building during the cold season for passive heating

Active

- In case of artificial heating, make provision for proper insulating material to avoid additional heat loss

11 Building envelope

Should be selected according to the local climate:

- Materials with low U-values are appropriate for hot and dry climates
- Materials with high U-values are appropriate for hot and humid climates

FOUNDATIONS

- Foundations should be appropriate for the conditions on the site - topography, water table level, soil type and depth of bedrock
- Foundations should be designed to meet the necessary structural, thermal, termite and moisture or water control (water proofing) requirements
- Porous back fill material (gravel, sand) should be used against the foundation walls to promote drainage

SLAB

Ground floor slab

- Waterproof membrane (ground floor) for moisture control
- Specification of appropriate floor finishes for acoustic considerations

Suspended floor slab

- Light coloured to enhance day lighting
- Specification of appropriate floor finishes for acoustic considerations
- Provision of acoustic treatment of the slab (ceiling) depending on the use of the room or area

Horizontal sun shading devices
© UN-Habitat / Jerusha Ngungui

Vertical sun shading devices
© UN-Habitat / Jerusha Ngungui

Perforated walls and louvres for shading and ventilation © Tengbom Architects

Shading devices © UN-Habitat / Vincent Kitio

STRATEGY

WALLS

Hot and humid
- lightweight walls with low thermal capacity
- light coloured exterior to reflect solar radiation
- light coloured interior finishes to enhance day light

Hot arid
- heavyweight walls with high thermal capacity
- light coloured exterior to reflect solar radiation
- light coloured interior finishes to enhance day light

Hot semi-arid / savannah
- medium weight walls
- light coloured exterior to reflect solar radiation
- light coloured interior finishes to enhance day light

Lake region
- Medium to heavyweight walls
- light coloured exterior to reflect solar radiation
- light coloured interior finishes to enhance day light

Upland/ high upland
- medium to heavyweight walls
- light coloured exterior to reflect solar radiation
- light coloured interior finishes to enhance day light

Light colour interior finishes
© UN-Habitat / Jerusha Ngungui

ROOFS

Hot and humid
- lightweight roofs with low thermal capacity and high reflectivity
- well ventilated or well insulated to reduce heat gain

Hot arid
- heavyweight roofs with high reflectivity
- ventilated
- if roof is lightweight, the ceiling should be heavyweight

Hot semi-arid / savannah
- medium weight roofs with high reflectivity
- ventilated

Lake region
- medium thermal mass roofs
- well ventilated

Upland/ high upland
- medium weight roof with good insulation value

Local building materials © Matthias Kestel

12 Choice of building materials

Recommendations taking into account climate and sustainability:
- select materials with low embodied energy and low energy construction systems
- use naturally available materials
- use durable materials and components
- use locally available materials and technologies
- use materials with greater potential for reuse and recycling
- use adhesives with no/low Volatile Organic Compound
- use materials that are non-toxic and with minimal indoor pollution

Light coloured external finishes
© UN-Habitat / Jerusha Ngungui

13 External finishes
- use of light coloured external finishes to reflect unwanted solar radiation
- use of green walls to reduce overall temperature of the building

14 Renewable energy

On site generation of renewable energy:
- solar energy (solar PV and solar water heaters)
- wind energy
- biogas from biodegradable waste
- hydropower

Solar panels © UN-Habitat / Jerusha Ngungui

STRATEGY

15 Water efficiency

Incorporation of water efficiency strategies such as:

- rain water harvesting – to be used for cleaning, watering plants, flushing toilets etc.
- recycling of grey water – use of dual plumbing system
- use of water saving fixtures – dual flush systems, low flow taps etc.

16 Sanitation

- provision of environmentally friendly toilets and sewerage systems: bio-digesters, reed bed sewage systems, oxidation ponds etc.

17 Solid waste management

- Recycling non – biodegradable waste
- On site sewage treatment for institutions / buildings in absence of Municipal sewage systems
- Producing biogas using biodegradable waste
- Sorting of waste generated

18 Landscaping

Soft landscaping

- use of indigenous plants that require minimal irrigation should be incorporated in the design

Hard landscaping

- provision of permeable or porous paving materials (open joint pavers, porous concrete, paving stones, permeable clay brick pavements etc.) where appropriate

19 Storm water management

- provision of drainage
- provision of measures to mitigate storm water / rainwater run-off and replenish the water table - permeable paving, rain gardens, soakaways, ponds, swales, infiltration trenches etc.

20 Energy efficiency / appliances

Use of:

- solar water heating systems
- energy efficient bulbs, appliances etc.
- light level sensors
- occupancy / motion sensors
- behaviour change

Above ground plastic inflatable gasholder

© UN-Habitat / Vincent Kitio

Solar water heater

© UN-Habitat / Jerusha Ngungui

Hard and soft landscaping

© UN-Habitat / Jerusha Ngungui

REFERENCES

Gut, P. and Ackerknecht, D. (1993) ***Climatic Responsive Building: Appropriate building construction in tropical and subtropical regions.*** *Switzerland: SKAT.*

Kimeu, M. (2013) ***Sustainable Building Strategies in the Tropics.*** *Paper presented at UN-Habitat conference on Financing Green Buildings in Africa, Strathmore University, Nairobi, September 17-19, 2013.*

Konya, A. (1980) ***Design Primer for Hot Climates****. London: The Architectural Press Ltd.*

UN-Habitat and Politecnico de Milano (forthcoming) ***Sustainable Building Design for Tropical Climates: Principles and Applications for Eastern Africa.*** *Nairobi*

For more information, please contact:

The Urban Energy Unit
Urban Basic Services Branch
United Nations Human Settlements Programme (UN-HABITAT)
P. O. BOX 30030 - 00100 Nairobi, Kenya
Vincent.Kitio@unhabitat.org
www.unhabitat.org/urban-themes/energy/

Executed by UN-Habitat with the support of GEF and UNEP