PROMOTING ENERGY EFFICIENCY IN BUILDINGS IN EAST AFRICA

Urban Energy Technical Note

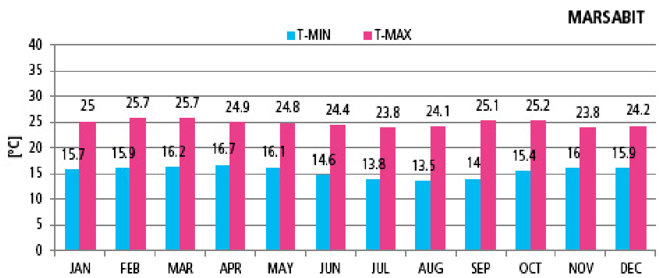
19

MARSABIT: Climate analysis and Sustainable Architecture

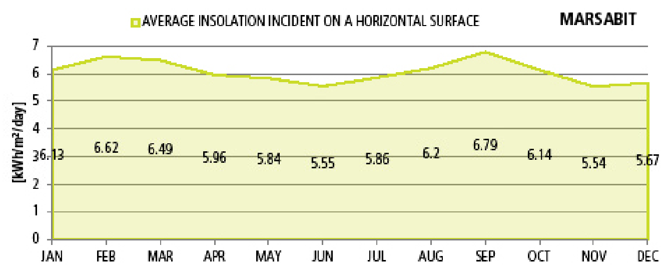
A well-designed building according to its respective climate can respond to the need for thermal comfort. Green building design strategies should address each of the following climatic data: temperature, solar radiation, relative humidity, rainfall and wind.

Climatic data charts

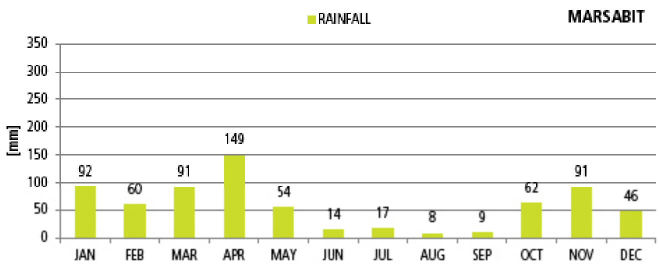
Temperature



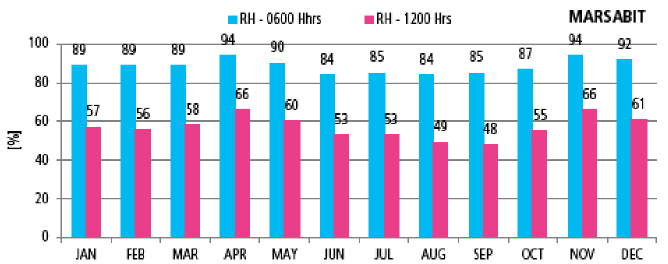
Solar radiation



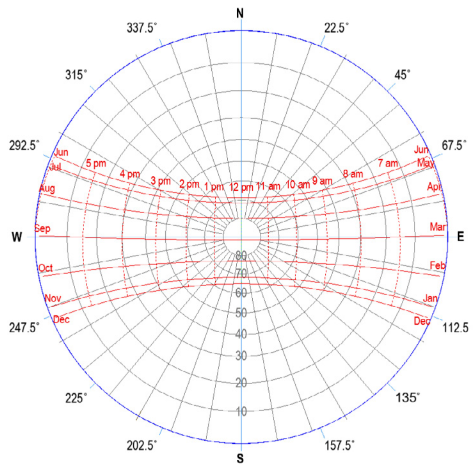
Rainfall



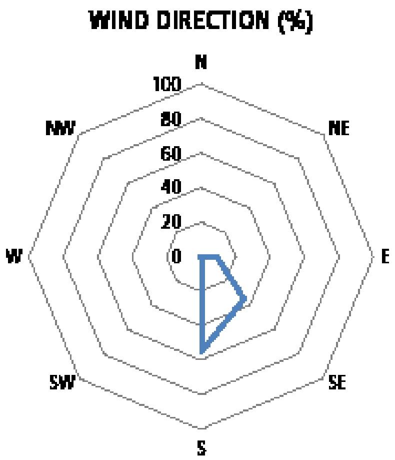
Relative humidity



Sun path diagram



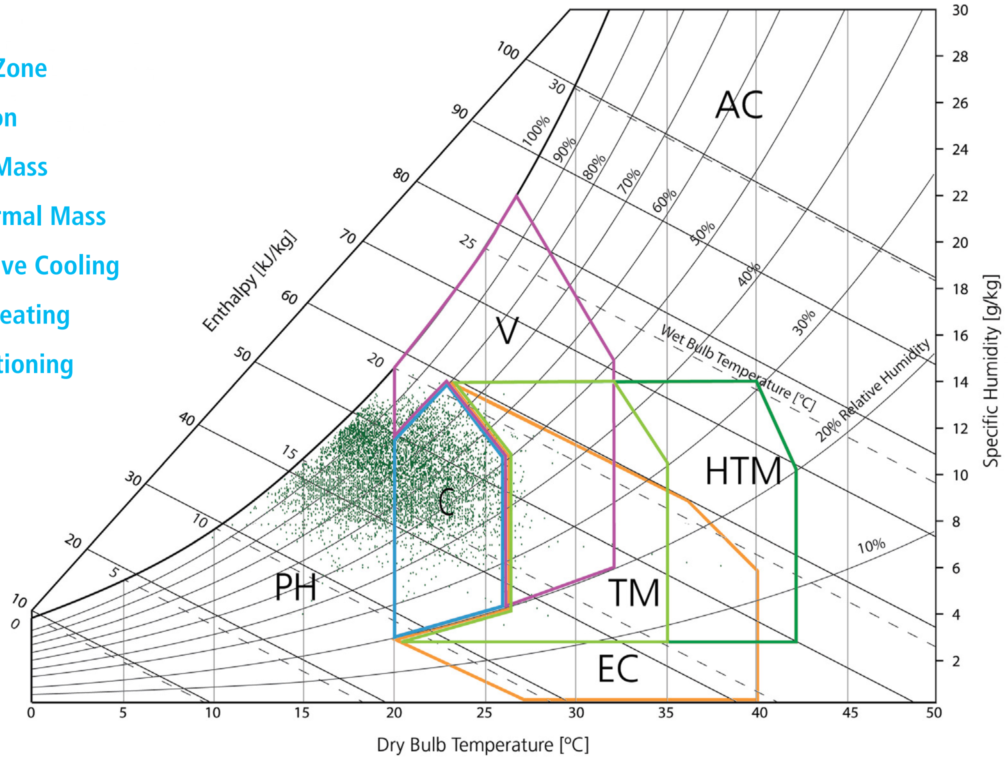
Wind rose diagram



Bioclimatic chart

The Givoni bioclimatic chart below shows temperature vs relative humidity and can be used to determine human thermal comfort and design strategies required for a particular location.

C	Comfort Zone
V	Ventilation
TH	Thermal Mass
HTM	High Thermal Mass
EC	Evaporative Cooling
PH	Passive Heating
AC	Air conditioning



Guidelines for Green Building Design

According to the climatic data for Marsabit, a green building should observe the following aspects:

BUILDING CONFIGURATION

- Compact buildings with courtyard to enhance protection from solar radiation.

BUILDING MATERIALS

- Heavy weight building materials in walls and roofs (30 cm and above): heavy weight stone (thick walls), concrete blocks, bricks, rammed earth, adobe, soil stabilized blocks, other local materials with similar characteristics.
- Air conditioning should not be necessary with an appropriate building design. However, for those cases that it is needed, high insulation factor in walls and roofs and tight openings should be considered.

OPENING SIZES AND SOLAR PROTECTION

- WWR: 15% to 25%. Small windows are preferred to larger ones to prevent solar gains.
- Maximize openings in north/south façades and minimize in east / west façades.
- Protection of openings from solar radiation using solar shading devices that should not cause glare.

NATURAL VENTILATION

- Use of horizontal and vertical ventilation strategies.
- Openings should be closed during the day and opened at night to cool the building through night ventilation.
- Provision of openings in different axes to maximise cross ventilation.
- Smaller openings should be located on external walls while larger openings should open to the patio or courtyard.

PASSIVE COOLING

- Maximization of evaporative cooling and night-purge ventilation.
- Use of vegetation and water features to enhance evaporative cooling during the day.

BUILDING ENVELOPE (ROOF AND WALLS)

Roofs

- Heavy weight materials and high reflectivity roofs.
- Provision of openings to allow vertical ventilation at night (vents just under the roof or on the roof).
- Ventilated roofs, flat roofs or domes are appropriate for this climate.

Walls

- Heavy weight materials with thermal inertia to prevent heat transmittance during daytime.
- Solar radiation protection (overhangs, verandas, trees etc.)
- Light colour exterior and interior finishes to reflect solar radiation.

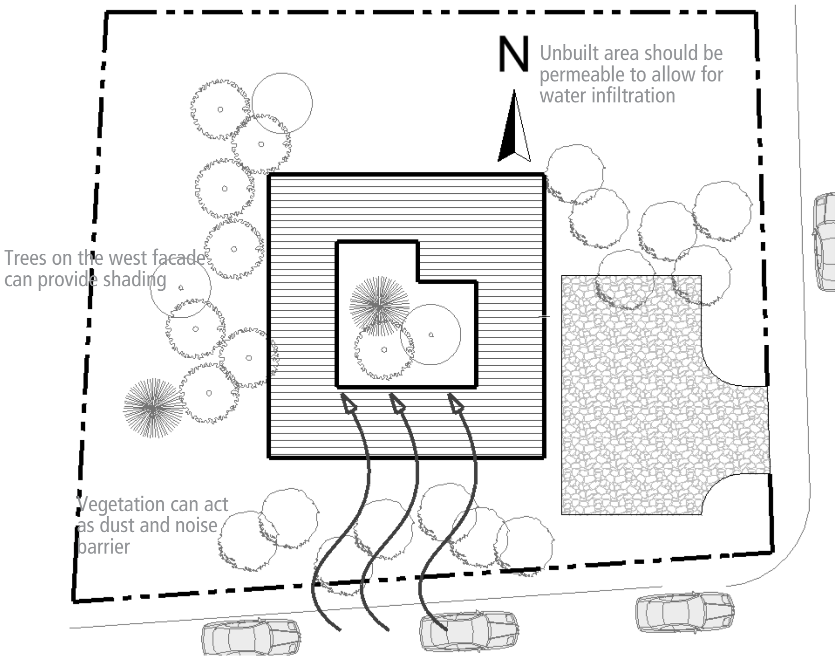
Design Guidelines

Because of the high daily temperature variation, it is best to keep the heat out during the day and ventilate during the night in order to achieve a well-balanced indoor climate. This can be achieved in the following ways:

Site plan

- A good site plan provides solar access during the cold season of the year and adequate sun protection and ventilation in warm seasons.
- The building footprint should not exceed 60% of the total plot area. The remaining area should be permeable (green) to ensure rainwater infiltration (natural draining) and avoid the Urban Heat Island (UHI) effect

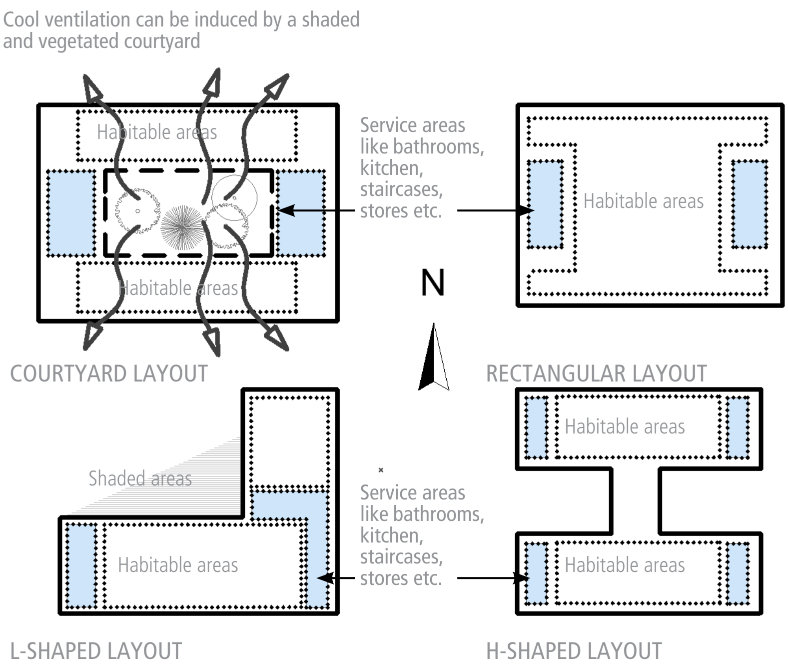
Conform to the permitted ground coverage



Building form and configuration

- Buildings need to be compact, provide shade and have controllable ventilation. These compact forms result in reduced surface areas of heat gain.
- Buildings should be appropriately oriented along the east and west axis with larger dimensions facing north and south. West facing orientation is the worst and should be avoided.
- An appropriate building plan and proper space zoning can ensure heat gain reduction and optimum day lighting.
- Placing services spaces on the east and west ends of the building can act as thermal barriers

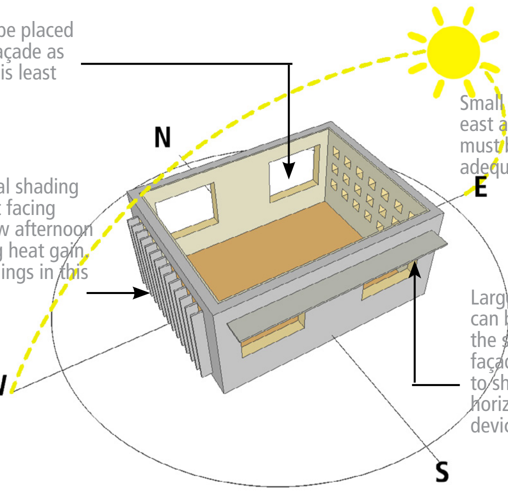
Various appropriate building layout options



Shading strategies

- The most important building design strategy for comfort in hot arid climates is shading.
- Orienting the building with the long sides facing north and south, as well as placing minimal to no openings in the east and west facing façades, reduces excessive solar gains.
- Shading of all glazed areas by the use of sun shading elements (vertical fins, roof overhangs, balconies, egg-crate devices, vegetation etc.) can be used to minimise solar heat gains.
- Roofs receive a great deal of solar radiation and should therefore be insulated to minimise heat gain.
- Compact layout suitable for hot arid climates results to mutual shading of buildings and creation of cool and desirable outdoor spaces.

Orientation based shading strategies



Shading using horizontal devices (left) and vertical devices (right)

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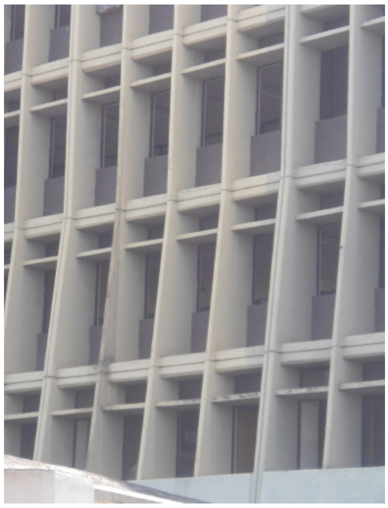

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Openings and windows

- Openings and windows are necessary for day lighting and natural ventilation.
- Main openings should face north and south and should be adequately shaded by either horizontal shading devices, roof overhangs etc.
- East and west facing windows should be avoided or minimised to reduce heat gains in the early morning and late afternoon. If unavoidable, they should also be shaded using appropriate devices.
- 10 - 20% of the area of the north and south facing windows should be operable.
- Tight closing joints and window profiles are important to prevent the penetration of hot air, dust and insects.
- Openings should be placed such that they take advantage of the prevailing wind direction to allow for natural ventilation through the building.
- Inlet openings should be at the level of occupants while outlets should be located at a high level where hot air accumulates.
- Casement type of openings are recommended for this type of climate as they allow for good airtightness during the day and have the largest effective open area for ventilation at night.

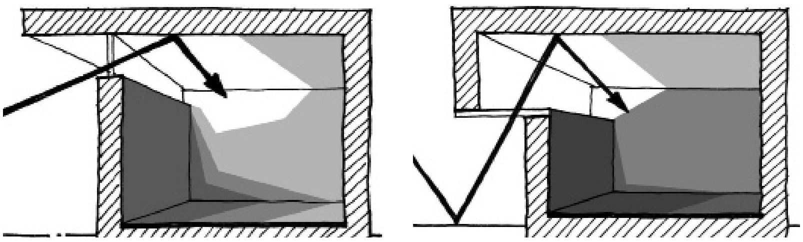
Appropriate and well-designed sun shading devices can dramatically affect indoor conditions such as indoor illumination from daylight, solar heat gains and glare.

Daylighting

Buildings in hot and arid climates tend to have small openings to minimise heat gain and reduce glare. Optimum day lighting can therefore be achieved in the following ways:

- high level windows to admit reflected light on the ceiling;
- low level windows opening onto a shaded / vegetated courtyard;
- use of internally reflected light;
- use of nonreflective shading devices to avoid glare.

Opening types allowing the reduction of glare in a hot-arid climate



High-level windows

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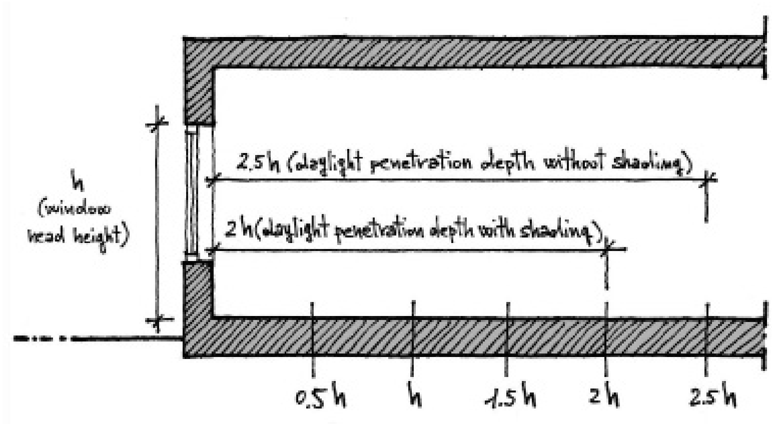
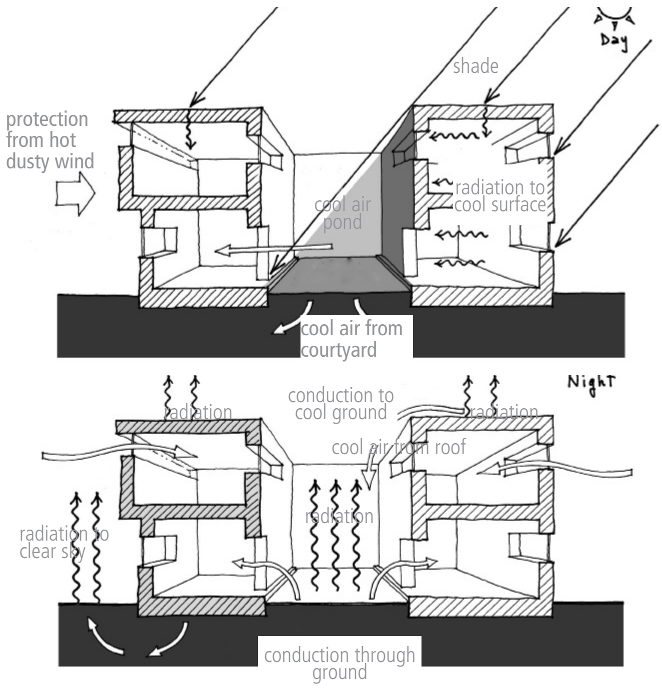
Dimensions for appropriate daylight distribution



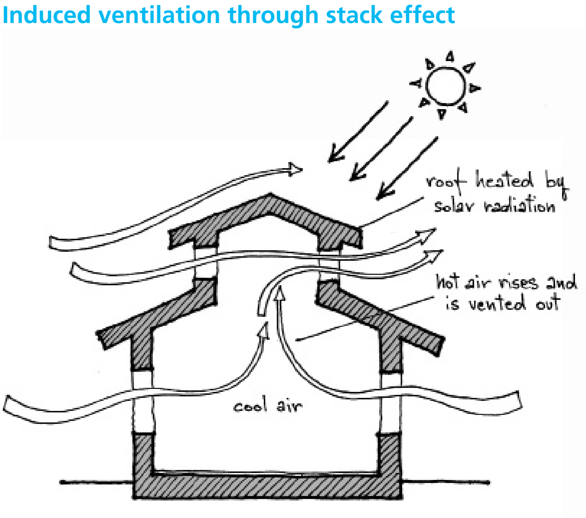
Natural ventilation

- In hot arid climates, natural ventilation during daytime should be avoided and night ventilation should be favoured for cooling the structure.
- Both cross and stack ventilation strategies should be explored for passive cooling.
- Roofs should be well ventilated and sloped towards prevailing breezes.
- Courtyards provided with water and vegetation promote cooling through evapotranspiration.

Cooling system in a courtyard house

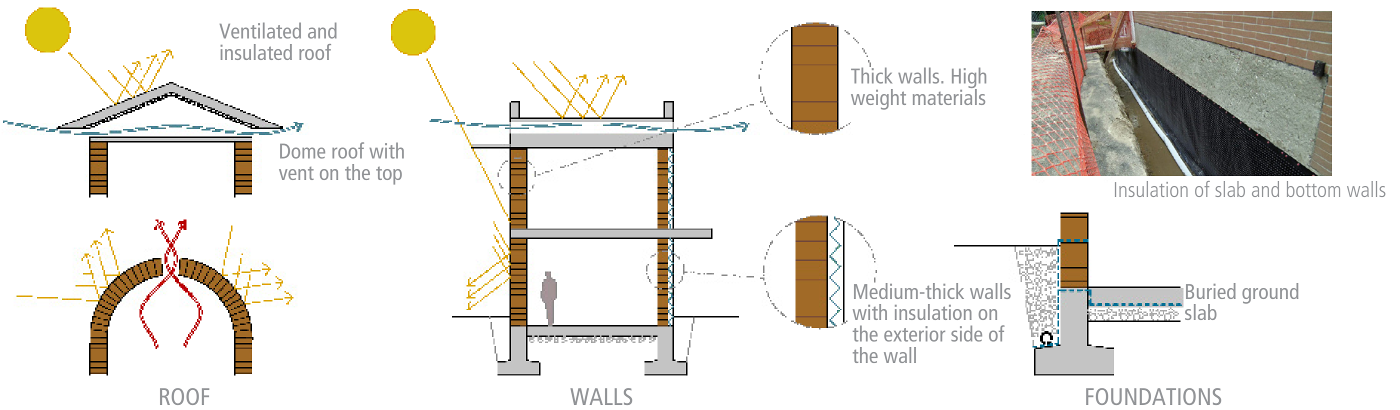


Induced ventilation through stack effect



Structure

Walls	Roof	Foundations	Finishes
Heavy weight building materials are recommended because of high daily temperature swing	Heavyweight materials and high reflectivity surfaces. Roofs should be ventilated	Semi buried ground floors to create cave effect and increase indoors natural cooling can help to maintain indoor comfort in this climatic zone	Light external colours to reflect solar radiation and light internal colours to improve daylighting
Materials: high-weight 40 cm stone walls; heavy thick concrete blocks walls; 40 cm rammed earth or stabilized soil blocks walls	**Materials:** stone or earth ventilated dome; well insulated and ventilated iron sheet; ventilated roof made of clay tiles or iron sheet with insulating ceiling	**Materials:** stone; reinforced concrete; concrete blocks; burnt bricks	**Materials:** light coloured paint; light coloured natural soil plaster; white cement; lime.



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Energy

- Renewable energy sources such as solar, wind, biomass etc. can be integrated into the building to generate electricity. This can be inform of photovoltaic systems to harness solar energy or small scale building integrated wind turbines to harness wind energy.
- Solar thermal systems in the form of flat plate, evacuated tube collectors use solar energy for domestic hot water heating.
- Improved cook stoves are preferred as they result in: a reduction in indoor air pollution and Green House Gas (GHG) emissions; fewer respiratory diseases; improved health to users due to reduced exposure to smoke; and reduced fire hazards in the kitchen.
- Biodegradable wastes from toilets, animal dung or crops can be used to generate energy in the form of biogas, which is a clean renewable energy that can be used for cooking and lighting.
- Energy efficient appliances, equipment and lighting fixtures should be installed.

Solar hot water system and photovoltaic system installed on a roof

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Water conservation and efficiency

- Rainwater should be harvested and used for cleaning, flushing toilets and watering plants.
- Grey water, which is generated from indoor uses such as bathrooms, sinks, showers, tubs and laundries can be treated and reused for toilet flushing or irrigation.
- An efficient plumbing system should be designed by locating the wet areas (kitchen, laundry and bathrooms) adjacent or close to each other.
- Efficient plumbing fixtures such as low-flow or aerated taps and showerheads, dual-flush toilets, waterless toilets and urinals reduce water wastage.
- Landscaping using local plants that are adapted to the local climate ensures that minimal water is required for irrigation.
- Permeable paving inform of loose aggregate, well-spaced paving stones, permeable vegetated surfaces etc. allow for water infiltration they minimising surface run off from surfaces such as parking areas, walkways etc.

Rainwater harvesting

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Permeable paving - stone slabs with grass joints

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