Rainwater harvesting:
This method of water collection provides good quality water. Sufficient storage tanks for the collection of rainwater must be ensured. It can be collected, stored and re-used onsite, for gardening and landscape irrigation. Green roofs can also contribute to this method. If the water is properly treated, it can be used for drinking/ cooking purposes.

Surface run off:
In tropical countries, water run off is generated by rainfall. When the rainfall rate on a surface exceeds the ground infiltration capacity, it can cause erosion or flooding. Mitigation of these effects can be achieved by minimizing impervious surfaces and providing a good drainage system with a storm drain.

Step 6: Solid Waste

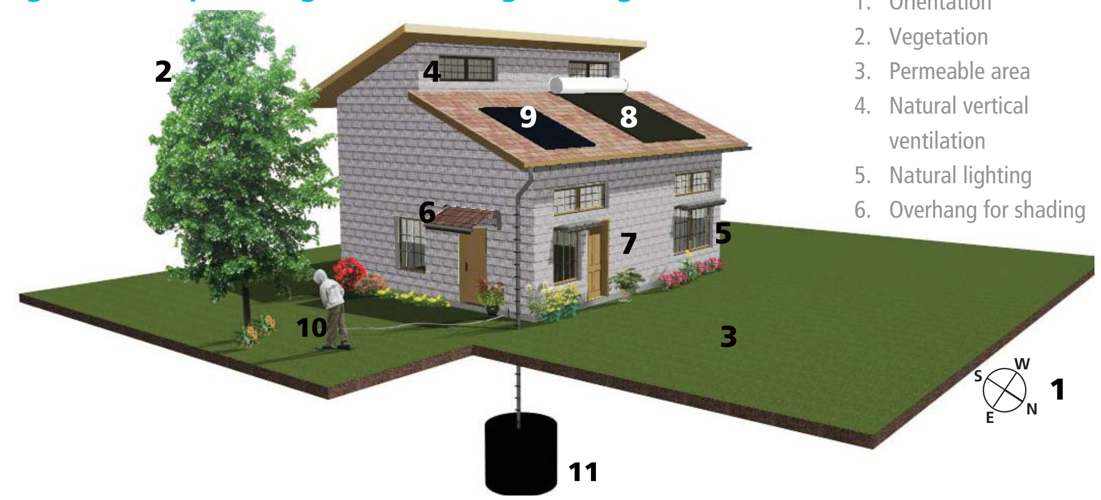
Solid waste recycling: Household garbage sorting is the first step of a sustainable Solid Waste Management System. Onsite sorted waste disposals and a communal garbage collection should be put in place.

Domestic waste production for landfills can be reduced by more than 50% if sorting is performed at household level, followed by a recycling community program. Materials such as glass, paper, plastic and aluminium can be reused or recycled. Organic waste can be used for compost or used to generate energy through biogas.

Step 7: Agriculture

Urban agriculture:
This involves the growing of plants (for food or non-food production) and raising animals in urban areas. It is a part of the urban system, integrated into the urban economy and is interactive with the ecological system. This strategy has many positive points, i.e. offers work for urban residents, makes use of organic waste (fertilizer) and wastewater (irrigation); and has a direct link with consumers, due to its physical proximity.

Fig. 04 Examples of green building strategies



1. Orientation
2. Vegetation
3. Permeable area
4. Natural vertical ventilation
5. Natural lighting
6. Overhang for shading
7. Local building materials
8. Solar Water Heaters (SWH)
9. Solar Home System (SHS)
10. Waste water reuse
11. Rain water collection

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The purpose of this Technical Note is to call reader's attention to new technical issues in the field of sustainable human settlements development . They are not meant to be final or exhaustive. For more information, contact the Urban Energy Unit. Prepared by Vincent Kitio, Marja Edelman, Rachel Patrick-Patel and Jerusha Ngungui

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01

Urban Energy Technical Note

Guidelines for Green Building Design

Over 70% of the world energy generation is consumed in human settlements, resulting in an emission of more than two thirds of CO_2 that contributes to climate change. Widespread energy poverty and the increasing cost of fossil fuels are impacting negatively on the economic development and the living conditions of people.

The way buildings are planned and designed today has a direct implication on their energy bills.

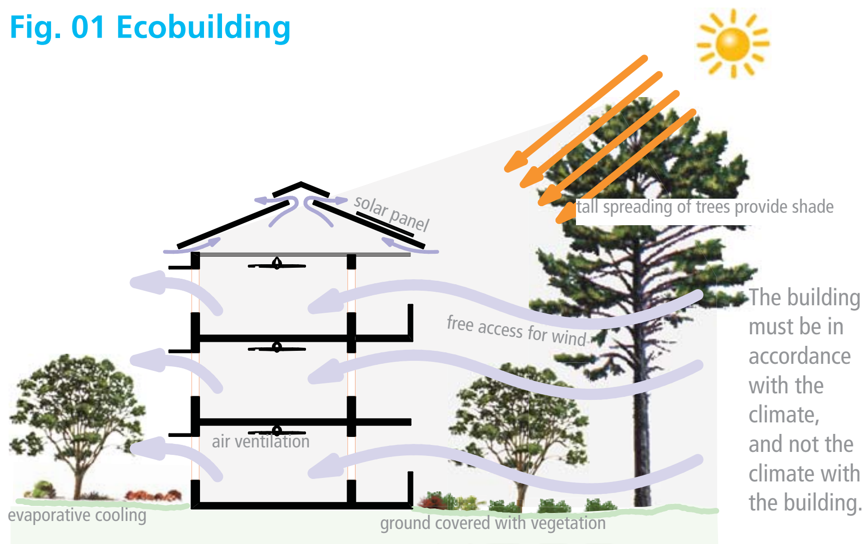
To address the global challenges of climate change and the high cost of energy it is essential to adopt urban planning and building design methodologies that are energy conscious and environmentally friendly. This document acts as a guideline to provide some of the mandatory criteria that should be taken into consideration. These criteria include:

- Optimization of the structure's energy efficiency;
- Minimization of the energy demand of buildings;
- Maximization of the efficiency of energy supply;
- Maximization of the share of renewable energy sources.

To design an energy efficient built environment involves minimizing the wastage of resources while maximizing the use of renewable energy sources and passive building design options.

This technical note introduces a simplified path to sustainable design, accessible through 7 Steps.

Fig. 01 Ecobuilding



Step 1: Site Analysis

Site analysis helps to identify opportunities or constraints which will influence the outcome of the urban design.

Sun Path:
Understanding the movement of the sun during the day and throughout the year allows for a qualitative analysis of the sunlight or shading of a site or part of a building. It is very useful for estimating the effects of the neighbouring buildings' shading or sunscreen needs. In the tropics, the orientation of the main road path should be developed along the East-West axis.

Prevailing Winds:
Knowledge of the speed and directions of the prevailing winds will facilitate natural ventilation. The main road orientation should follow the prevailing wind direction to assure natural ventilation and dust removal to all buildings along the road. A compromise should be taken in case the prevailing winds direction are in conflict with the sun path.

Site Topography:
The existence of rivers, streams, valleys, hills, mountains; may assist or obstruct natural cooling, wind and sun shading. Proper site analysis is required to maximize the use of the existing micro climate.

Vegetation:
Helps in regulating temperature and dust reduction in urban areas. Trees act as wind breakers and produce oxygen through photosynthesis.

Step 2: 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.

Building Orientation:
The building should be developed along the East-West axis, and its main façades (where the major openings are located) should face either North or South to minimize direct exposure to solar radiation.

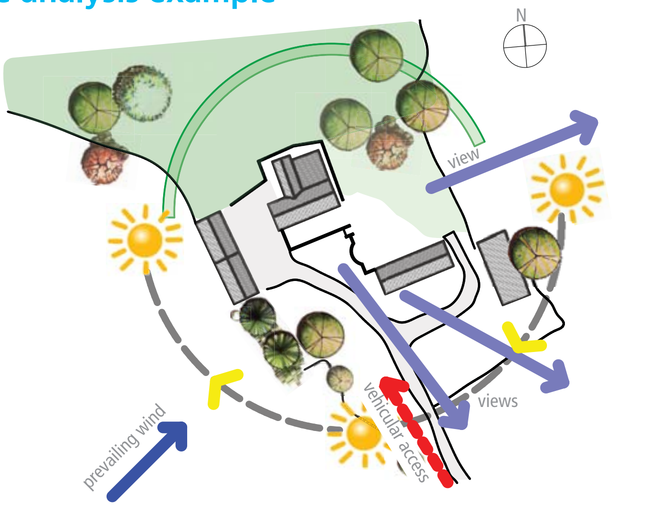
Building Position:
The distance between buildings might differ according to the climatic zone. In any case, attention must be paid to avoid hampering of natural light. The tropical humid climate requires a minimal distance of 3m in urban areas to allow the wind to flow between buildings, assisting natural ventilation.

Building Footprint:
This should not exceed 50% of the total plot area (30 or 40%). The remaining area should be permeable (green) to ensure rainwater infiltration (natural draining) and avoid the Urban Heat Island (UHI) effect.

Drainage:
Existing natural drainage patterns should be maintained around existing vegetation. Sustainable drainage slows down the accumulation and flow of water into drainage points (storm water drainage or sewer).

An Urban Heat Island (UHI) is a metropolitan area which is significantly warmer than its surrounding rural areas. This effect is due to the modification of the land surface by urban development and the lack of vegetation. A large proportion of the materials used in urban areas retain heat (i.e. concrete and asphalt, commonly used for pavement and roofs), resulting in higher temperatures in these areas.

Fig. 02 Site analysis example



Step 3: Building Design

Orientation and layout:
In tropical climates, the building orientation allows for maximum protection from solar radiation and optimum ventilation. It is advisable to minimize East-West building surfaces: main façades should face North-South. Regarding ventilation, it is recommended to position inlet openings within 35° of the wind direction.

Building layout should be designed in order to place living areas (rooms, living-rooms, and kitchen) in the North-South direction. Service rooms, staircases and toilets can be placed on the East-West side. The kitchen's position in the house is often neglected, but it is a space where many people spend much of their daily life. Proper ventilation of the kitchen using openings and chimneys should be catered for.

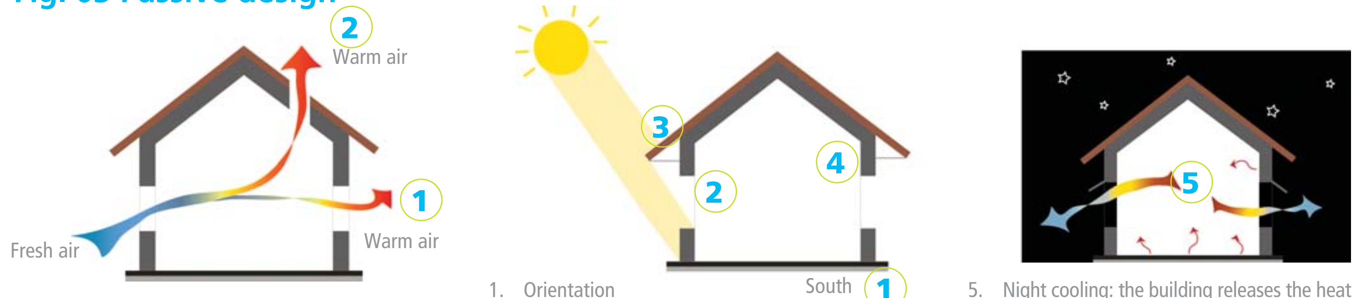
This will avoid indoor air pollution and reduce the risk of fire. Energy efficient stoves could also be integrated in the building design.

Openings:
Large openings (doors and windows) are very important in tropical humid climates, but they should be effectively protected from solar radiation. Openings in East and West façades should be avoided or limited to a minimum. Selective glazing should be acknowledged. Indoor spaces such as kitchens and bathrooms should have external windows for natural ventilation.

Natural ventilation:
Frequent replacement of indoor air with fresh air is necessary to improve indoor comfort and hygiene. There are two categories of natural ventilation: cross ventilation and vertical ventilation. The first category depends on the building shape and wind speed /direction. Inlet openings should be regularly distributed, and located on the wind-ward side at a low level. The outlet windows should be located on the opposite side. The second category is called "Stack effect" and is caused by the difference of temperature between inside (warmer) and outside air.

Natural Lighting:
Daylight reduces the need for artificial lighting inside the building. The building should be designed in order to maximize natural lighting and optimize favourable outside views for better comfort. High reaching windows provide the best distribution of light. Openings in the roof are also a good option, provided that there is shading to reduce the heat gain.

Fig. 03 Passive design



1. Cross ventilation
2. Stack effect: the warm air is lighter than the cold air, and so it rises.

1. Orientation
2. Windows
3. Overhang for shading
4. Thermal mass (local stones)

5. Night cooling: the building releases the heat accumulated during the day, openings in the upper part of the windows can be used to remove it.

Roof:
A sloped roof avoids infiltration problems due to storm water retention. Alternatively, adequate green roofs (application of vegetation on the roofs) helps to decrease internal temperatures, purifies urban air, and acts as sound insulation. Openings on the roof can be used for vertical ventilation. Pitched roofs should have ventilation openings at eaves level.

Sun Shading:
The design of overhangs for shading from the sun should be incorporated into the design of the building. According to the orientation of the building, vertical/horizontal and fixed/ moving shading devices can be used. These features are common in tropical colonial architecture.

Materials:
The selection of the type of building material depends on the climatic zone. In a tropical highlands such as Nairobi, use materials of high thermal mass (stones), for the construction of walls. These materials store heat during the day and release it at night when indoor temperatures are higher than the outdoor temperatures. In tropical humid zones, light materials for example, wood is more appropriate as it does not store heat. Use local materials to support the local economy and avoid pollution as a result of transportation.

Colours:
Light colours indoors, reflect daylight, increasing its benefits. On the roof, use light-coloured surfaces which reflect more sunlight and absorb less heat.

Step 4: Energy

Solar energy:
With an appropriate urban design, buildings are oriented along the East-West axis. Solar energy systems can be installed on the roofs, making use of the abundant solar radiation existing in the tropical countries.

- Solar Water Heaters (SWH): this system uses solar energy to heat domestic water. SWH are composed of a collector and insulated storage tank. It is placed on the roof top. Once the system is installed, there are no running costs beyond annual maintenance. The electricity bill can be reduced by up to 60%, if it is sized correctly.
- Solar Home Systems (SHS): this technology comprises of Photovoltaic (PV) modules, wiring, a control panel, batteries to store electricity and an inverter. The PV modules have a lifetime of at least 25 years. They can be an integral part of the building envelope, replacing cladding or roof tiles; or even being used as shading elements. Solar PV panels can be used to shade parking lots and generate additional electricity for the community. Other options are the "Solar Mini-Grid Systems", that provide energy for small communities and "Solar Street Lighting" for public uses.

Wind:
Wind turbines transform the energy in the wind into mechanical power, that can generate electricity or be used directly, to pump water. Wind power depends on the wind constancy, speed, direction and turbulence. Small wind generators are designed to be used in urban areas.

Biogas:
Organic solid waste can produce energy (heat or electricity) through anaerobic digesters. It can be used as a source of small scale power generator or energy for cooking. Biogas technology has been used in municipal land filed to generate electricity.

Biomass:
Firewood and charcoal are the main cooking fuel for the majority of the urban poor. Improved cooking stoves should be promoted as they significantly reduce the fuel needed for cooking.

Step 5: Water

Wastewater Recycling:
This is an essential strategy in a sustainable neighbourhood. Waste water can be collected and treated in a household-scale system. The water may be used for flushing toilet water. If it is used directly after production, the recycled water doesn't need to be treated if used for garden watering. The waste water from kitchen sinks, dishwashers and toilets is not usually collected as it is heavily contaminated. Given that a municipal sewage system is not likely to be available for the coming years, it is recommended to consider an onsite sewage treatment system.