Urban Energy Technical Note

02

Climate and Architecture

Climate is described as the average course or condition of the weather at a place usually over a period of years as exhibited by temperature, wind velocity, precipitation and humidity.

A shelter or a building is designed to protect its occupants from the adverse conditions of the weather. As we choose our clothing according to the seasons, buildings' envelop should be designed to respond to its micro-climate. It can respond to the need for thermal comfort. Green building design strategies address each of the following climatic data: temperature, solar radiation, relative humidity, rainfall and wind.

The way buildings are planned and designed today has a direct implication on the energy consumption, hence they have a strong potential to negatively or positively impact two important elements of everyday life: our environment and energy bills. Their contribution to climate change mitigation on greenhouse gas emission is directly related to the way they are designed in relation to local climate, the site specific characteristics and the embodied energy of the entire construction process.

Other characteristics that influence the buildings include: topography, presence of water bodies, surrounding buildings, vegetation etc. The influence of the sun should be understood and respected by designers of passive solar buildings in which the sun's free energy is used in the building for lighting and heating, but will not interfere with the occupants' comfort.

Climatic regions in East Africa

Climatic conditions in East Africa differ from region to region and are divided into five main distinct climatic regions: Hot and Humid, Hot Semi-arid/Savannah, Hot Arid, Highland / Upper highland and Lake Region. Given these varied climatic zones, it is therefore clear that different regions require specific design solutions. There is no model solution that can be applied across the board.

Well-designed buildings according to the different climatic conditions in East African Countries can passively respond to the adversity for thermal comfort by using its positive values (such as allowing in air movement for natural ventilation and daylight for natural lighting) and keeping away the adverse elements (such as protection against solar radiation).

Thermal comfort is described as a person's condition of mind which expresses satisfaction with the indoor and outdoor environment. Factors affecting thermal comfort include air temperature, radiation, air velocity, humidity, clothing and metabolic rate (activity)

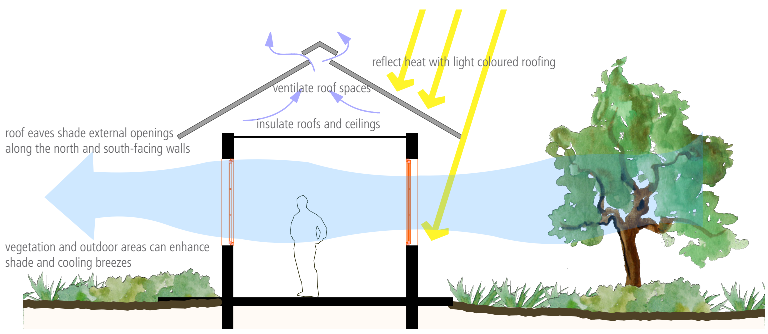
Importance of climatic data

Climate is an essential consideration in the process of architectural design and has a major effect on the performance of a building and its energy consumption. Knowledge of climatic conditions therefore helps building professionals to develop appropriate responsive designs and consequently select suitable materials that meet climatic constraints. Considering the importance and scale of the construction industry this represents an important step for climate change adaptation and mitigation. To achieve this, access to detailed climatic data is needed. In this way, a natural form of climate adaptation with energy consumption reduction can be attained.

A good integration of climatic data associated with environmentally sound building design measures could save up to 70 per cent of energy in buildings.

This technical note presents climatic data of different regions in East Africa necessary to guide the design of energy efficient buildings.

Fig. 01: **Integration of climatic data into building design**

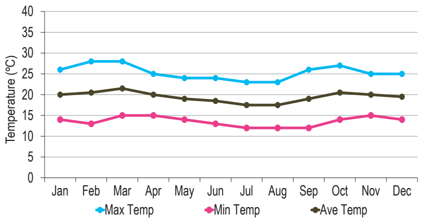


Nairobi, Kenya

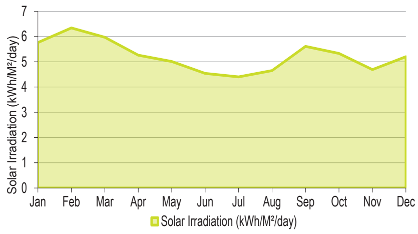
CLIMATIC ZONE: **HIGHLANDS**

Altitude: 1,800 m • Latitude: 1°17´S • Longitude: 36°49´E

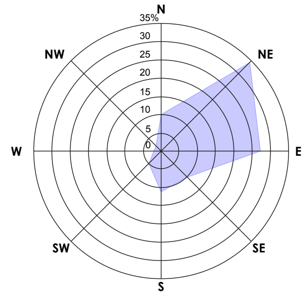
Climatic charts



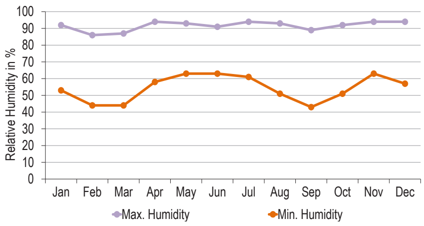
Temperature
Maximum and minimum temperatures are key factors for thermal comfort



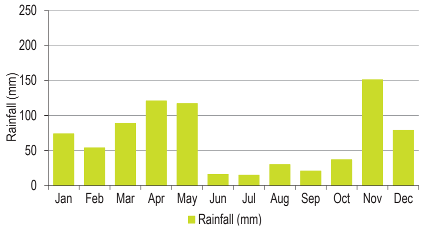
Solar Radiation
The intensity of the solar radiation influences the building heat gains



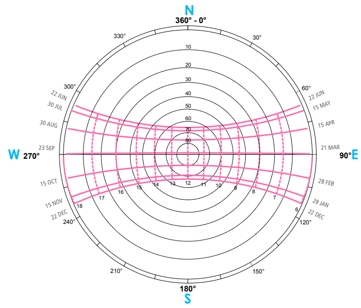
Wind Rose
A wind rose diagram shows the wind directions in a particular location. This is useful to create natural ventilation



Relative Humidity
Maximum and minimum relative humidity determine the dryness of the atmosphere and the feeling of warmth or cold

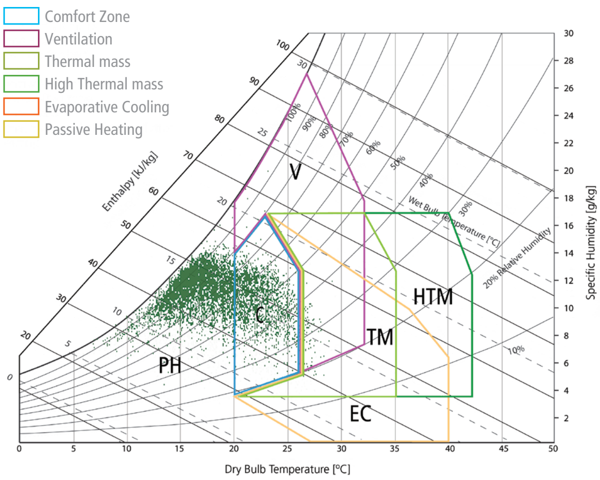


Rainfall
Monthly rainfall influences the relative humidity and is useful for designing water rain harvesting systems



Sun Path
The sun path of a particular location is crucial for designing proper sun shading devices

Bioclimatic chart



The bioclimatic chart shows temperature vs humidity and can be used to determine human thermal comfort and design strategies required for a particular climatic zone.

Guidelines for Green Building Design

According to the climatic data for Nairobi, a green building should observe:

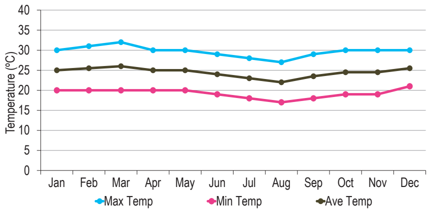
- Building orientation with main façades facing North-South
- Natural ventilation should be provided making use of the prevailing winds from NE-E direction
- Natural lighting in all the rooms but preventing solar radiation will reduce energy consumption
- Protection of windows from direct solar light but allowing some solar radiation to enter the building in the colder season from May to September will enhance passive heating
- High thermal capacity walls (made of stones or bricks) are very appropriate to assist passive heating during the colder season

Dodoma, Tanzania

CLIMATIC ZONE: **SEMI ARID / SAVANNAH**

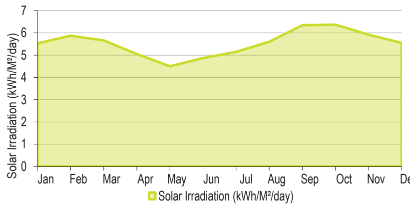
Altitude: 1,120 m • Latitude: 6°10´S • Longitude: 35°44´E

Climatic charts



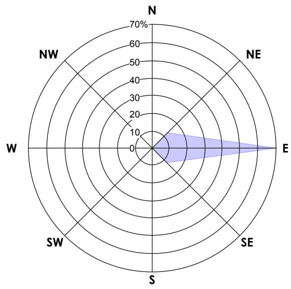
Temperature

Maximum and minimum temperatures are key factors for thermal comfort



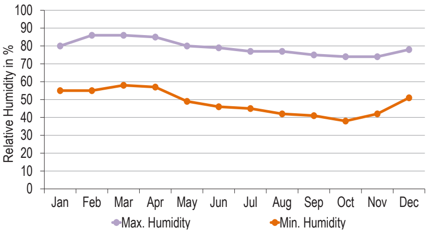
Solar Radiation

The intensity of the solar radiation influences the building heat gains



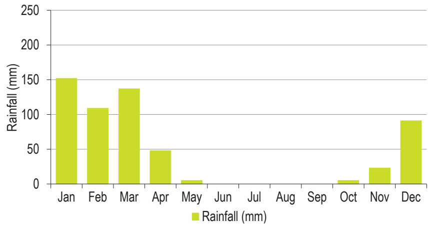
Wind Rose

A wind rose diagram shows the wind directions in a particular location. This is useful to create natural ventilation



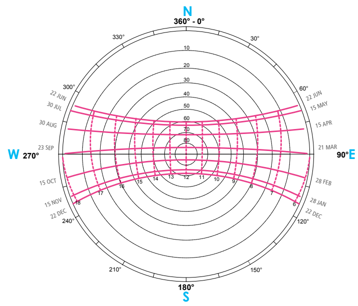
Relative Humidity

Maximum and minimum relative humidity determine the dryness of the atmosphere and the feeling of warmth or cold



Rainfall

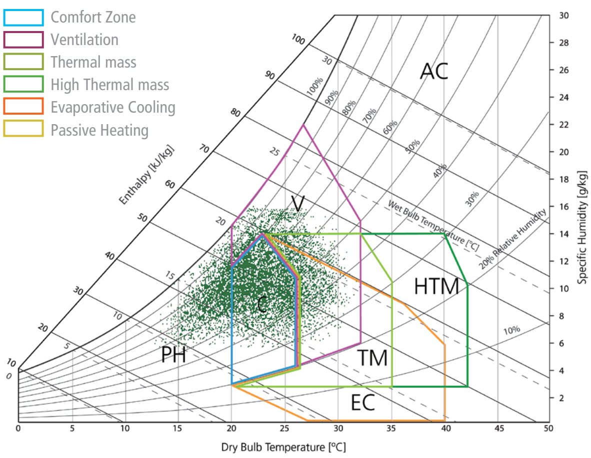
Monthly rainfall influences the relative humidity and is useful for designing water rain harvesting systems



Sun Path

The sun path of a particular location is crucial for designing proper sun shading devices

Bioclimatic chart



The bioclimatic chart shows temperature vs humidity and can be used to determine human thermal comfort and design strategies required for a particular climatic zone.

Guidelines for Green Building Design

According to the climatic data for Dodoma, a green building should observe:

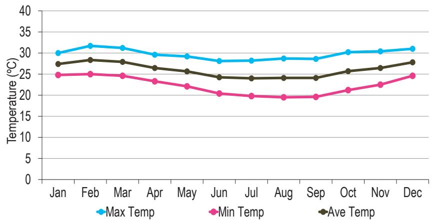
- Orientation with long axis running east-west to provide effective shading
- Major windows should be oriented on North and South facing walls as they receive less solar radiation
- Compact buildings to reduce the façades exposed to solar radiation
- Use of medium to heavy weight materials with high thermal mass
- Well ventilated and high reflective roofs of high thermal mass
- Ventilation should be limited during day time, when the air is hot but allow for good natural night ventilation
- Protection of all openings from direct and / or indirect solar radiation
- Evaporative cooling in the hottest days is recommended

Dar es Salaam, Tanzania

CLIMATIC ZONE: **HOT AND HUMID**

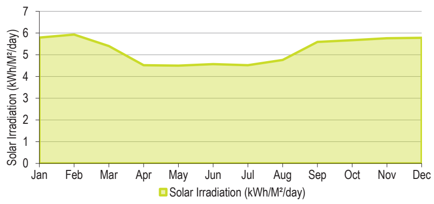
Altitude: 53 m • Latitude: 6°48´S • Longitude: 39°17´E

Climatic charts



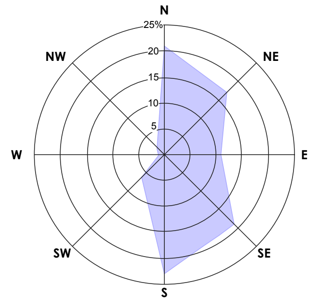
Temperature

Maximum and minimum temperatures are key factors for thermal comfort



Solar Radiation

The intensity of the solar radiation influences the building heat gains



Wind Rose

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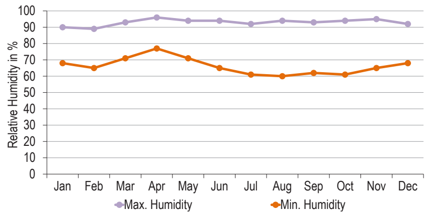

Relative Humidity

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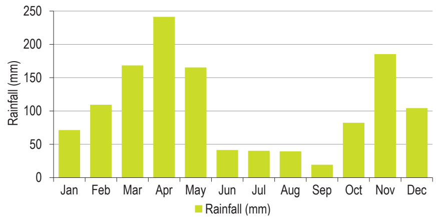
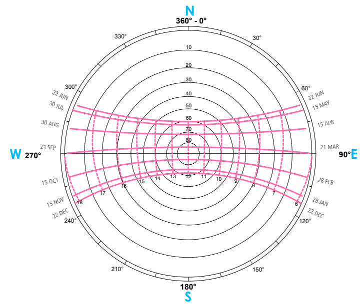


Rainfall

Monthly rainfall influences the relative humidity and is useful for designing water rain harvesting systems



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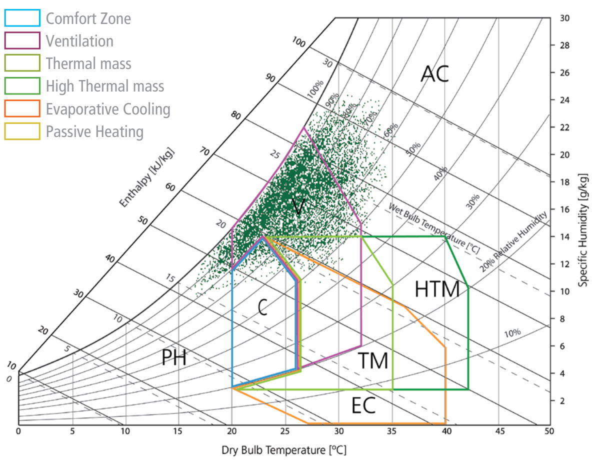
The sun path of a particular location is crucial for designing proper sun shading devices

Bioclimatic chart



The bioclimatic chart shows temperature vs humidity and can be used to determine human thermal comfort and design strategies required for a particular climatic zone.

Guidelines for Green Building Design

According to the climatic data for Dar es Salaam, a green building should observe:

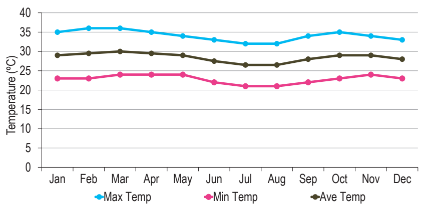
- Orientation along the east-west axis for maximum sun control
- Building should allow for maximum natural ventilation to provide cooling
- Protection of all openings from direct and / or indirect solar radiation
- Major windows should be oriented on North and South facing walls as they receive less solar radiation
- Use of lightweight materials (like thin walls or wood) with low thermal capacity for the walls
- Roofs should be well ventilated and made of lightweight materials with low thermal capacity and high reflectivity season
- Light colour finishes are desirable to reflect solar radiation

Garissa, Kenya

CLIMATIC ZONE: **HOT AND ARID**

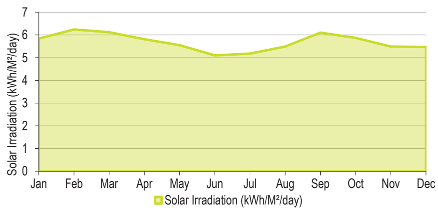
Altitude: 147 m • Latitude: 0°26´S • Longitude: 39°38´E

Climatic charts



Temperature

Maximum and minimum temperatures are key factors for thermal comfort



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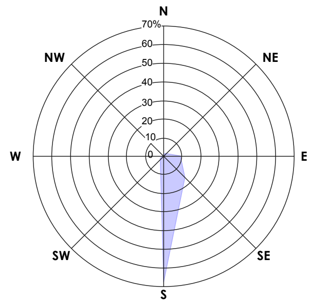
The intensity of the solar radiation influences the building heat gains



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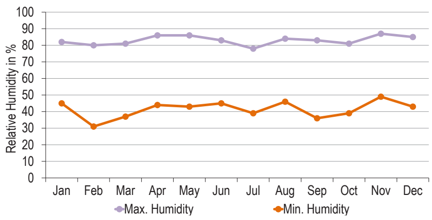

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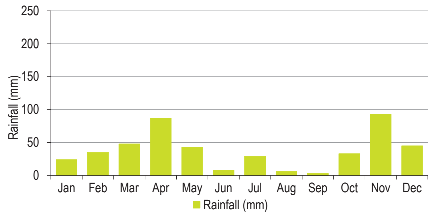

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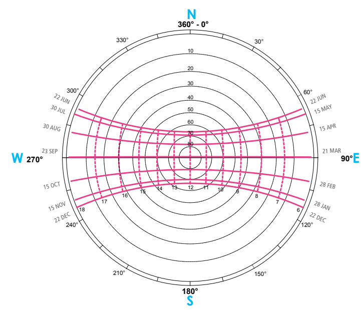

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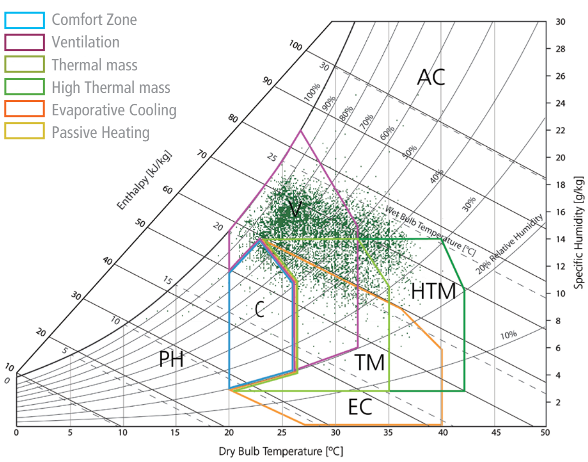


The bioclimatic chart shows temperature vs humidity and can be used to determine human thermal comfort and design strategies required for a particular climatic zone.

Guidelines for Green Building Design

According to the climatic data for Garissa, a green building should observe:

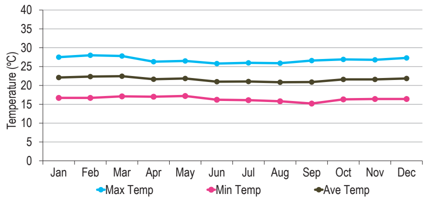
- Orientation with long axis running east-west for effective shading
- Major windows oriented on North and South facing walls as they receive less solar radiation
- Compact buildings to reduce the façades exposed to solar radiation
- Use of heavy weight materials with high thermal mass (like stones or soil bricks) to reduce indoor daytime and night time extreme temperatures
- Well ventilated and high reflective roofs of high thermal mass
- Ventilation should be limited during the day time when the air is hot but allow for good natural night ventilation
- Protection of all openings from direct and/or indirect solar radiation
- Evaporative cooling is effective because of the low relative humidity
- Courtyard typologies are also recommended for natural cooling

Kampala, Uganda

CLIMATIC ZONE: **LAKE REGION**

Altitude: 1,140 m • Latitude: 0°19´S • Longitude: 32°34´E

Climatic charts



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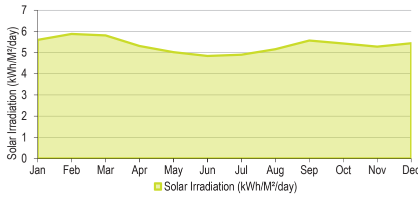

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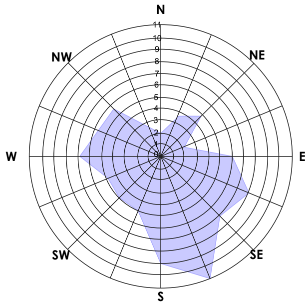

Wind Rose
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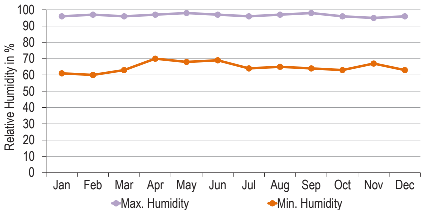

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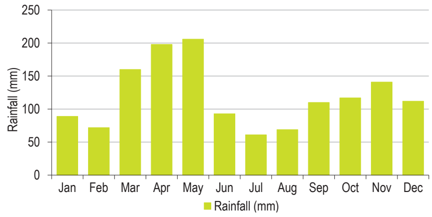

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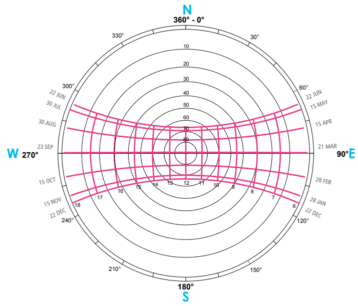

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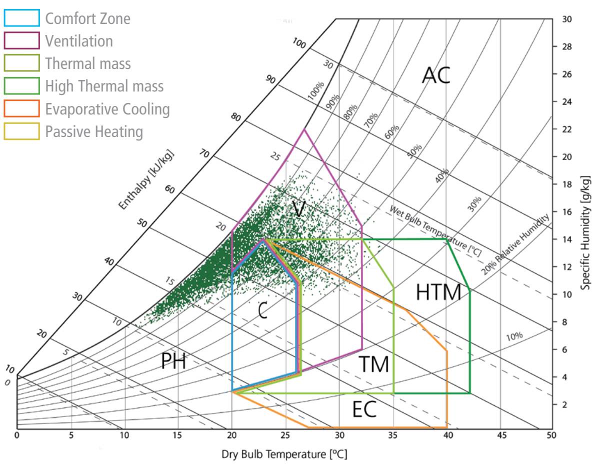
Bioclimatic chart



The bioclimatic chart shows temperature vs humidity and can be used to determine human thermal comfort and design strategies required for a particular climatic zone.

Guidelines for Green Building Design

According to the climatic data for Kampala, a green building should observe:

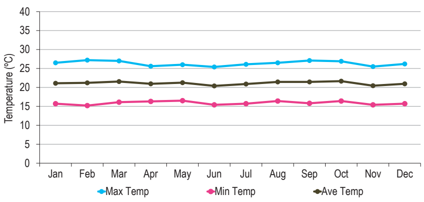
- Buildings should favour good natural ventilation
- Protection of all openings from direct and / or indirect solar radiation
- Orientation along the east-west axis for maximum sun control
- Major windows should be oriented on North and South facing walls as they receive less solar radiation
- Use of medium weight materials is recommended as night temperatures often fall below the comfort zone
- Roofs should be well ventilated and made of lightweight materials with low thermal capacity and high reflectivity
- Light colour finishes are desirable to reflect solar radiation
- Passive solar heating in the colder season

Kigali, Rwanda

CLIMATIC ZONE: **HIGHLANDS**

Altitude: 1,490 m • Latitude: 1°57´S • Longitude: 30°04´E

Climatic charts



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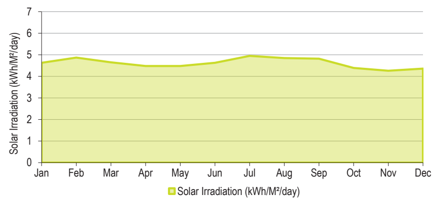

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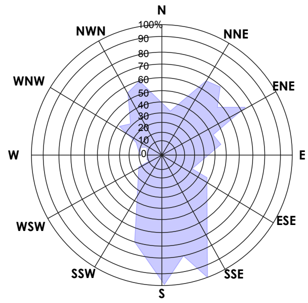

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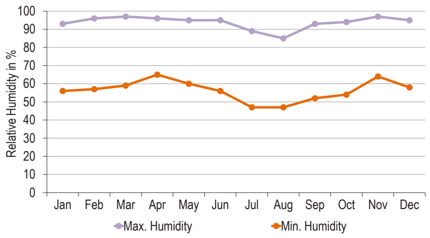

Relative Humidity

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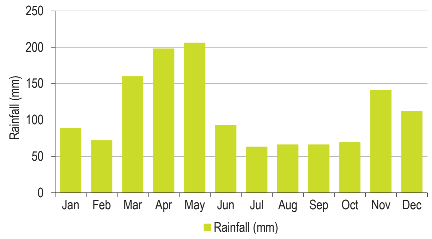

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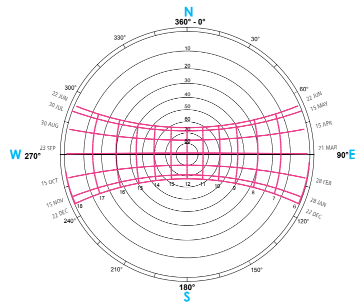

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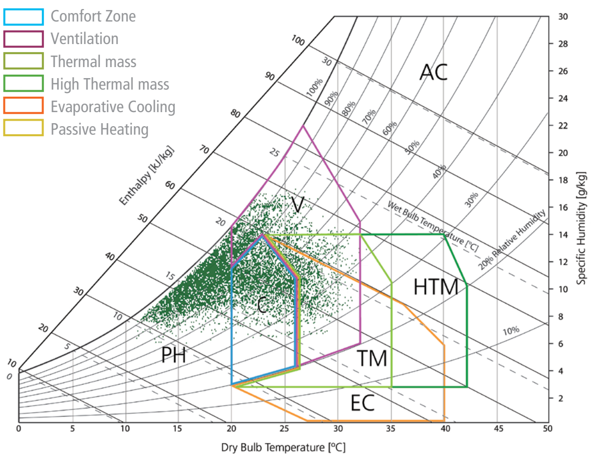

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Guidelines for Green Building Design

According to the climatic data for Kigali, a green building should observe:

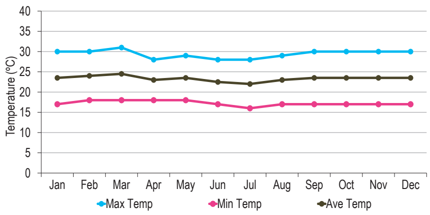
- Building orientation with main facades facing North-South
- Natural ventilation should be provided making use of the prevailing winds from NE-E direction
- Natural lighting in all the rooms but preventing solar radiation will reduce energy consumption
- Protection of windows from direct solar light but allowing some solar radiation to enter the building in the colder season from May to September will enhance passive heating
- High thermal capacity walls (made of stones or bricks) are very appropriate to assist passive heating in the colder season

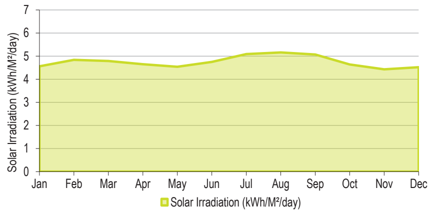
Bujumbura, Burundi

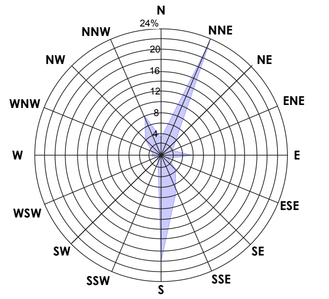
CLIMATIC ZONE: **LAKE REGION**

Altitude: 774 m • Latitude: 3°23´S • Longitude: 29°22´E

Climatic charts







Temperature
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Solar Radiation
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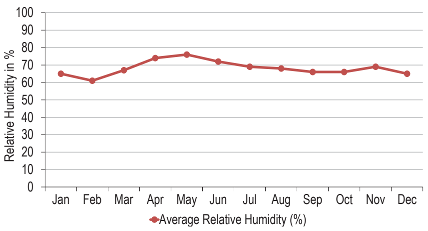

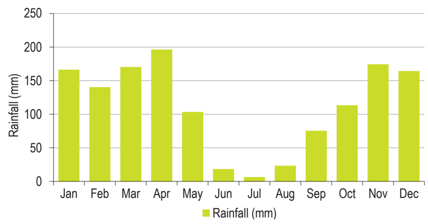

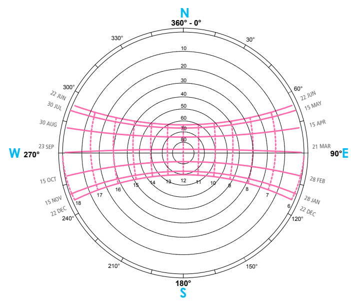

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Maximum and minimum relative humidity determine the dryness of the atmosphere and the feeling of warmth or cold

Rainfall
Monthly rainfall influences the relative humidity and is useful for designing water rain harvesting systems

Sun Path
The sun path of a particular location is crucial for designing proper sun shading devices

Guidelines for Green Building Design

The design strategies to be used in this region are similar to Kampala (p.6).

REFERENCES

EnergyPlus Energy Simulation Software - http://apps1.eere.energy.gov/buildings/energyplus

Energy Design Tool - Climate Consultant 5.4

UN-Habitat. (forthcoming) ***East African Climate Data and Guidelines for Bio Climatic Architecture.*** *Nairobi*

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

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/

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, Jerusha Ngungui and Zeltia Blanco.

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