The Future of Buildings in a World Currently Experiencing CLIMATE CHANGE

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1.0 INTRODUCTION

For the past 20 years or so, there has been growing international consensus that Global warming and Climate Change are occurring and that preventive action is necessary.

Evidence of warming of the climate system includes observed increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.

According to satellite temperature measurements, the temperatures near the Earth's surface have increased between 0.13 and 0.22 °C per decade since 1979. Temperature is believed to have been relatively stable over the one or two thousand years before 1850. This increase in temperature leads to global warming.

Despite the fact that warming of the earth is a natural part of the Earth's cycle, it is a global concern that human activities, particularly those that contribute to the colossal emission of CO2, are accelerating the rate of global warming. Human activities, since the start of the industrial era around 1750 have increased the levels of greenhouse gases in the atmosphere.

The 2007 assessment report compiled by the Intergovernmental Panel on Climate Change (I.P.C.C) observed that "changes in atmospheric concentrations of greenhouse gases and aerosols, land cover and solar radiation alter the energy balance of the climate system", and concluded that "increases in anthropogenic greenhouse gas concentrations is very likely to have caused most of the increases in global average temperatures since the mid-20th Century".

According to the "State of the Global Climate 2020 - Provisional Report" by the World Meteorological Organization, the following was reported:

1. **Concentrations of the major greenhouse gases, Carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (N_2O), continued to increase in 2019 and 2020.**

2. **Despite developing La Niña conditions, global mean temperature in 2020 was one of the three warmest on record. The past six years, including 2020, were the six warmest years on record.**

3. **Sea level has risen throughout the altimeter record, but recently sea level has risen at a higher rate due partly to increased melting of ice sheets in Greenland and Antarctica.**

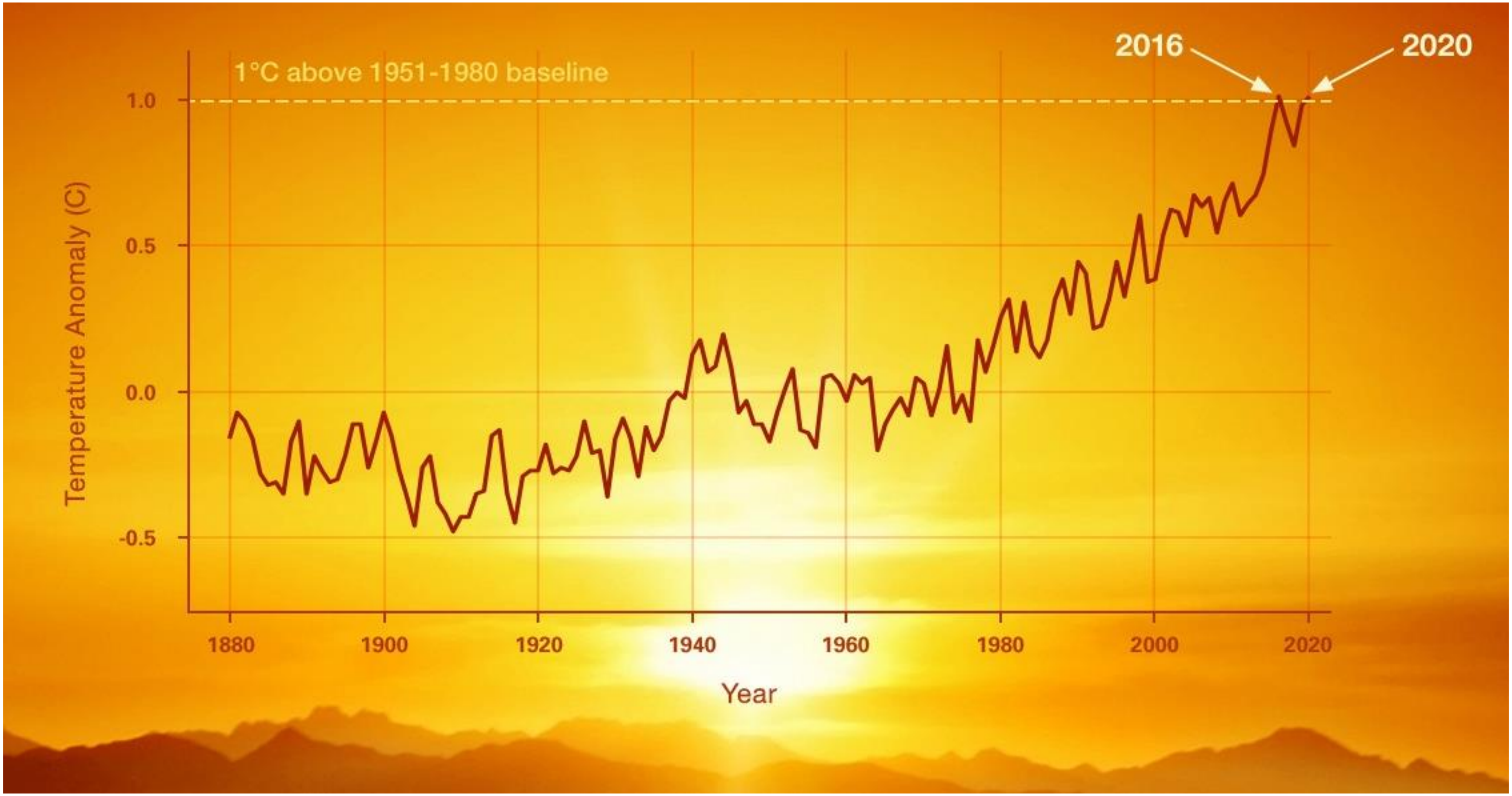
4. **2019 saw the highest ocean heat content on record.**

5. Heavy rain and extensive flooding occurred over large parts of Africa and Asia in 2020. In Africa, heavy rain and flooding affected much of the Sahel and the Greater Horn of Africa.

6. Severe drought affected many parts of interior South America in 2020, with the worst-affected areas being northern Argentina, Paraguay and western border areas of Brazil.

7. Climate and weather events have triggered significant population movements and have severely affected vulnerable people on the move, including in the Pacific region and Central America.

8. As of 17 November 2020, the north Atlantic hurricane season had its largest number of named storms on record with a record number making landfall in the United States of America.



This graph illustrates the change in global surface temperature relative to 1951-1980 average temperatures, with the year 2020 tying with 2016 for warmest on record (Source: NASA's Goddard Institute for Space Studies)

2.0 EVIDENCE OF CLIMATE CHANGE

1. **Global Temperature Rise**

   The planet's average surface temperature has risen by about 1.18 degrees Celsius) since the late 19th century, a change largely driven by increased carbon dioxide emissions into the atmosphere and other human activities. Most of the warming occurred in the past 40 years, with the seven most recent years being the warmest. The years 2016 and 2020 are tied for the warmest year on record.

2. **Warming Ocean**

   The ocean has absorbed much of this increased heat, with the top 100 metres of the ocean showing warming of more than 0.33 degrees Celsius since 1969. The earth stores 90% of the extra energy in the ocean.

3. **Shrinking Ice Sheets**

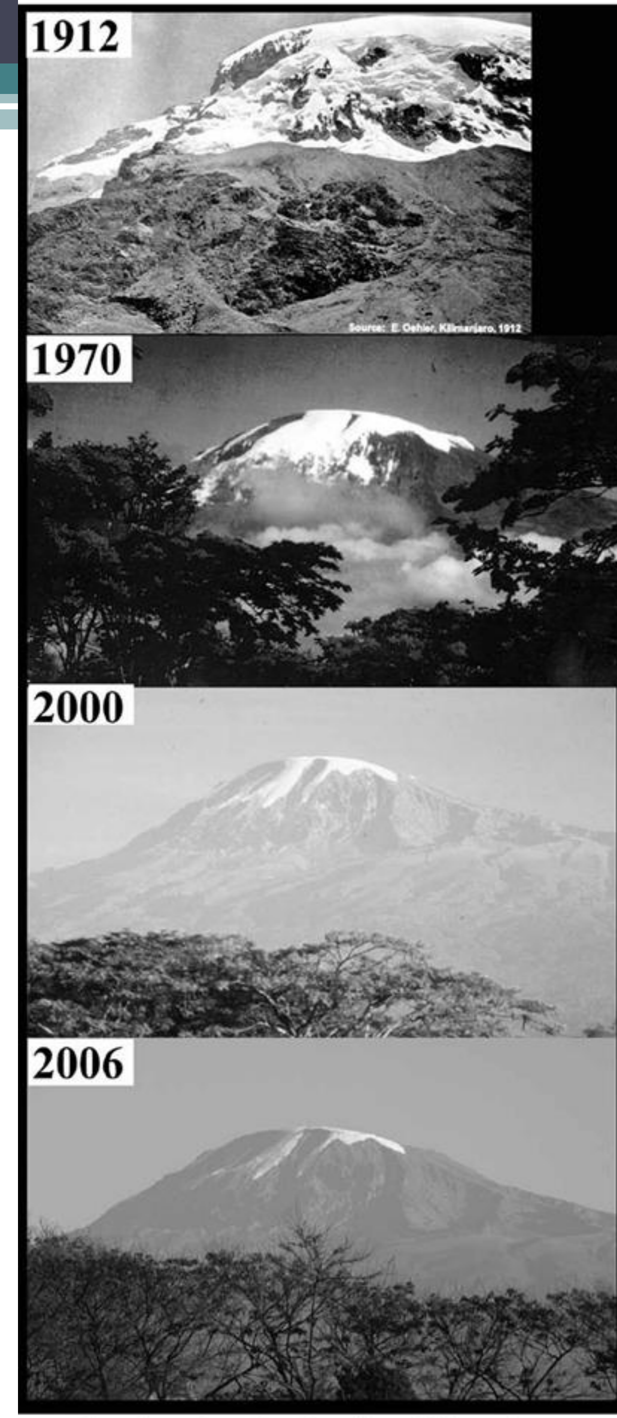
   The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost an average of 279 billion tons of ice per year between 1993 and 2019, while Antarctica lost about 148 billion tons of ice per year.

4. **Glacial Retreat**

   Glaciers are retreating almost everywhere around the world - including in the Alps, Himalayas, Andes, Rockies, Alaska, and Africa's Mt. Kilimanjaro and Mt. Kenya.

The disappearing snowcap of Mount Kilimanjaro, from space

The retreat of glaciers on Mount Kilimanjaro can be seen in the photographs from 1912, 1970, 2000, and 2006; from 1912 to 2006, 85% of the ice has disappeared



5. **Decreased Snow Cover**

   Satellite observations reveal that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades and the snow is melting.

6. **Sea Level Rise**

   Global sea level rose by about 0.2 metres in the last century. The rate in the last two decades, however, is nearly double that of the last Century and accelerating slightly every year.

THE CITY OF MALE, Republic of Maldives: Vulnerable to sea level rise

7. Longer periods of drought in some regions

8. An increase in the number, duration and intensity of tropical storms

Climate Change related Haboob in Sudan
A huge dust storm called haboob cover the Sudanese capital of Khartoum

Other evidence for rapid climate change include:

9. **Changes in Rainfall (Precipitation) patterns**

10. **Longer and more intense heat waves**

11. **More frequent wildfires**

etc

3.0 CAUSES OF CLIMATE CHANGE

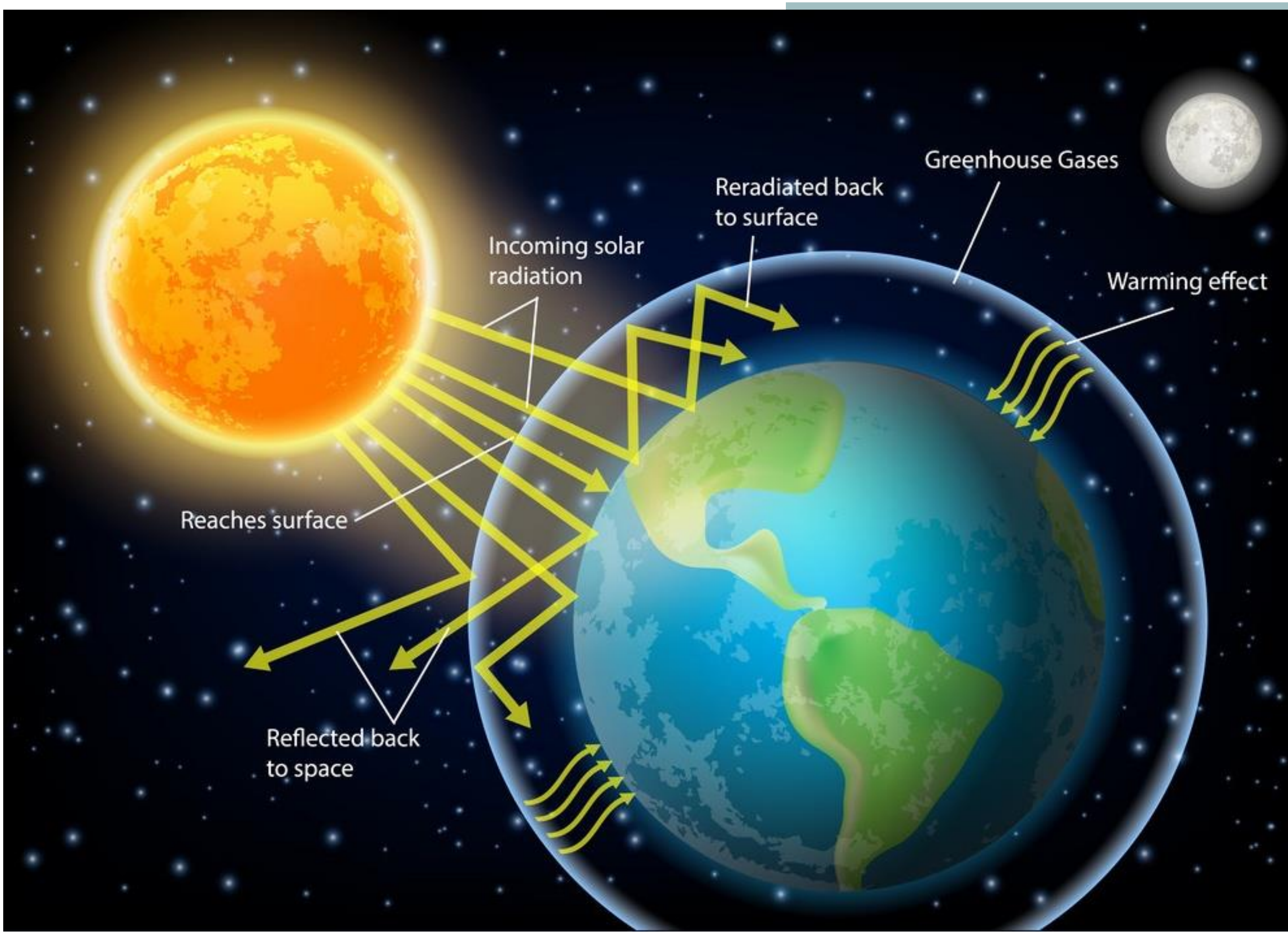
The balance between HEAT ENERGY from the sun and its loss back into space controls the temperature of the earth. The heat received from the sun is in the form of short-wave radiation. Once it strikes the earth surface, it is reflected back or absorbed and re-radiated by the earth as long-wave 'infra red' radiation. This process is part of the Earth's natural cycle of keeping it warm.

That notwithstanding, human activities including buildings' related activities, particularly those that contribute to the high emission of Carbon Dioxide (CO2) have accelerated warming of the Earth in unprecedented way and hence global warming.

Scientists attribute Global warming to human activities resulting in a 'Greenhouse effect'. This trend has been observed since the mid-20th Century.

It is a well established fact that the emission of GREENHOUSE GASES that are responsible for the 'greenhouse effect' are increasing in the atmosphere. These greenhouse gases act as a blanket layer that prevents long wave infra red solar radiation from escaping the earth surface as heat to outer space. Instead, the layer of greenhouse gases deflects the long-wave infra red solar radiation back to Earth, causing Global warming and the ongoing Climate Changes.

Gases that contribute to the 'Greenhouse effect' include but are not limited to water vapour, Carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (N_2O), Chlorofluorocarbons (CFCs), Hydro chlorofluorocarbons (HCFCs), Ozone (O3), Hydro fluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF6).



Greenhouse gases act as a blanket layer that prevents long wave infra red solar radiation from escaping the earth surface as heat to outer space

4.0 RELATIONSHIP BETWEEN BUILDINGS AND CLIMATE CHANGE

Architecture, like other industries is based on intense production and manufacturing with immense consumption of non-renewable resources and subsequent colossal emission of greenhouse gases. This can be traced back to the industrial revolution, about 270 years ago. The Industrial revolution started a spiral of limitless growth in the consumption of resources and in the consequential generation of Greenhouse gas emissions from the high Embodied Energy of the materials and waste production.

According to the World Green Building Council, buildings are currently responsible for 39% of Global energy related Carbon emissions: 28% from operational emissions, from energy needed to heat, cool and power them and the remaining 11% from materials and construction. Thus, the energy intensive building must be put under scrutiny.

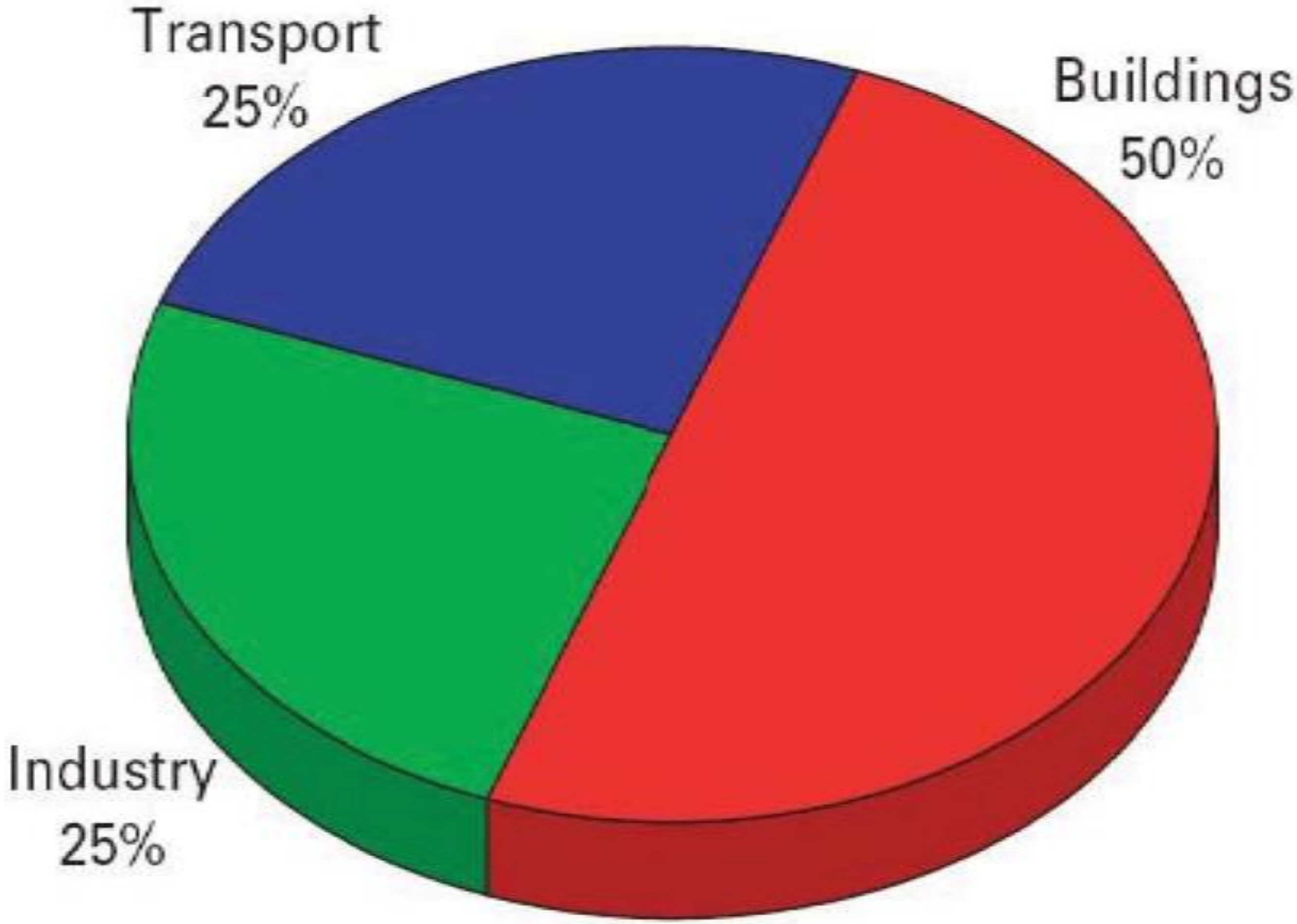
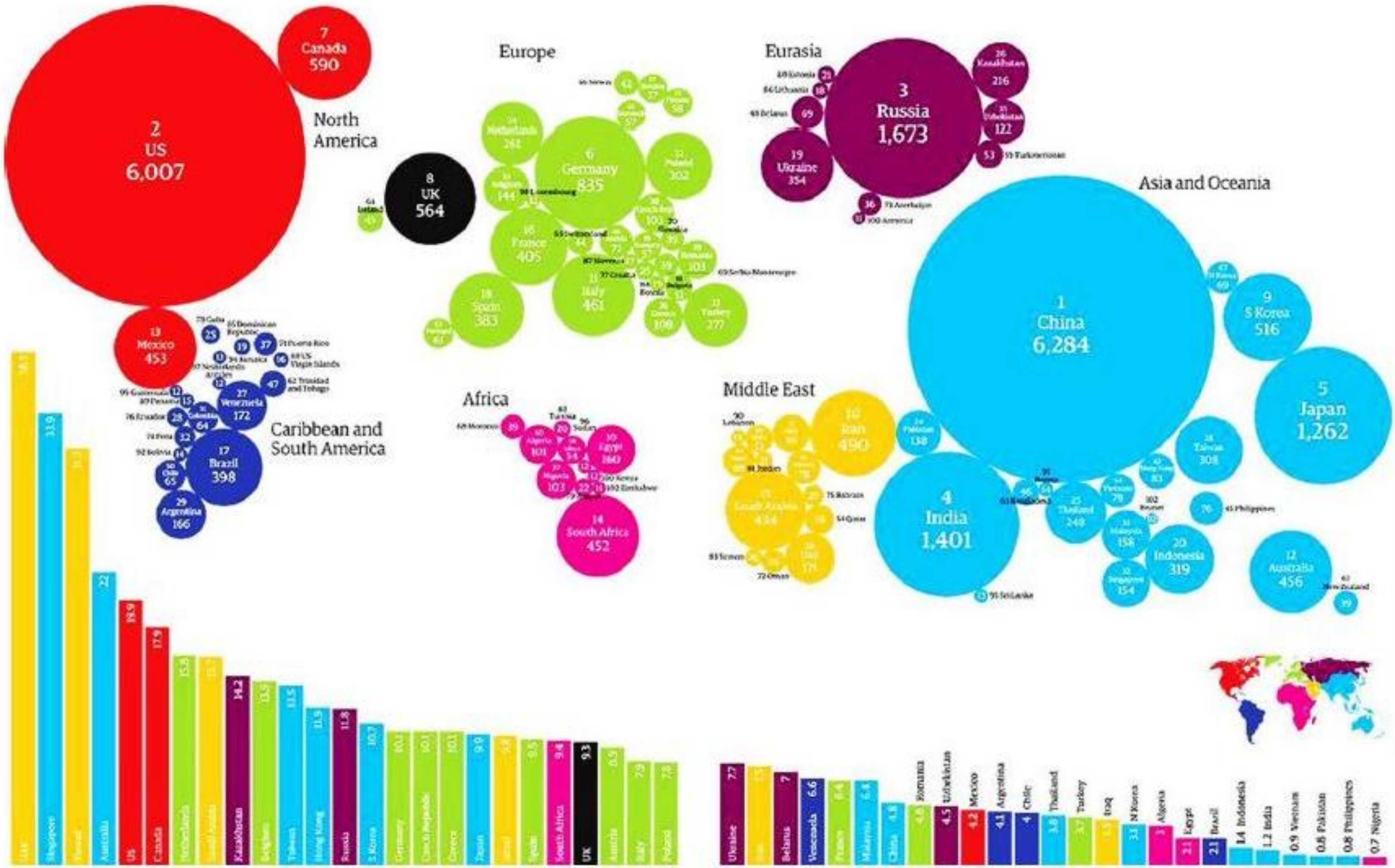
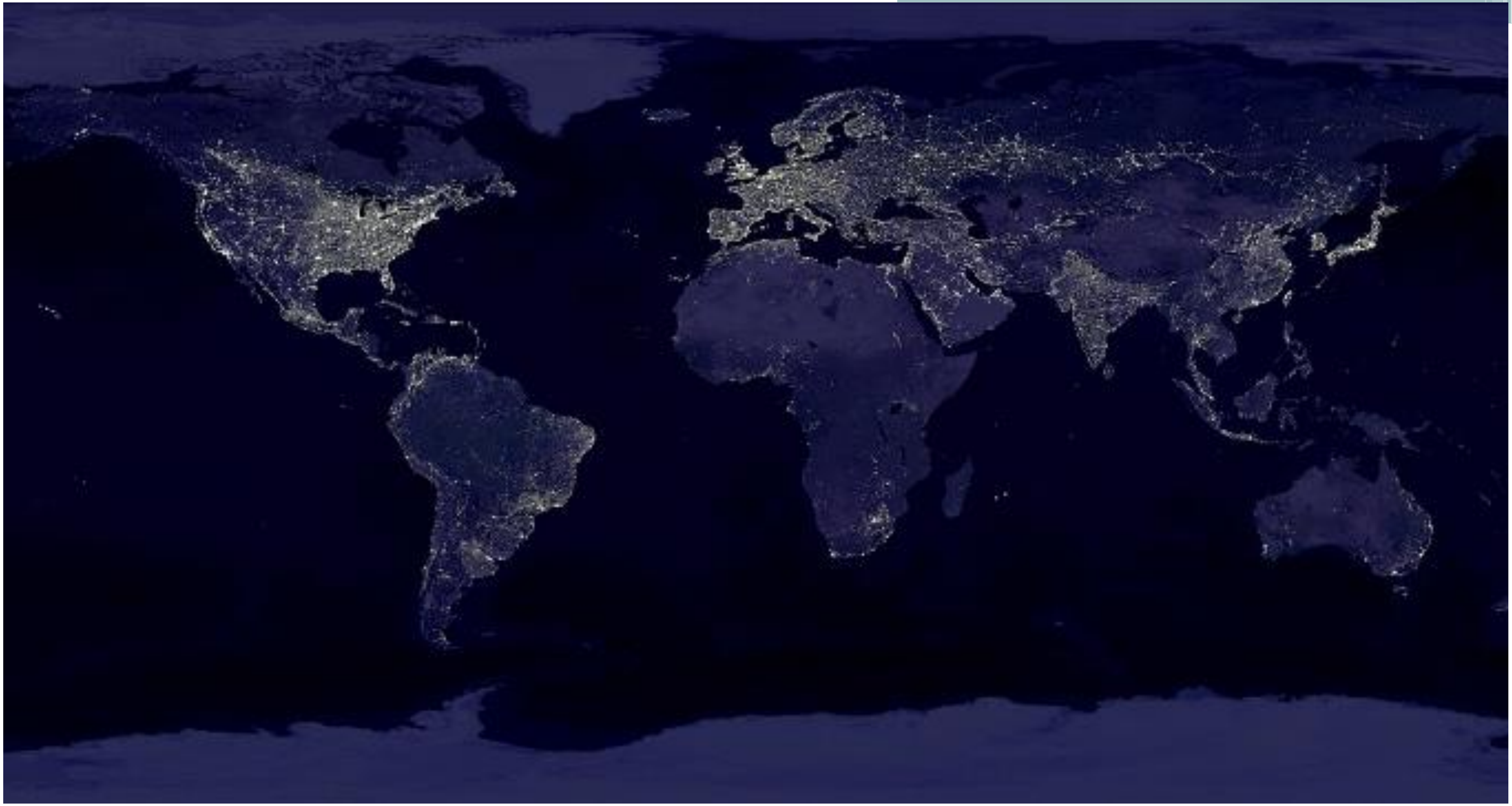


Chart showing relative emission of greenhouse gases by various human activities in the developed world

Global atlas of carbon emissions:





Map showing a composite image of lights (urban surface activity) on Earth. Bright lights = big cities. What is remarkably clear in this image is the energy usage in the United States of America, Western Europe and Japan as compared to Africa and the rest of the world. The major national and regional contributors to greenhouse gas emissions are evident.

While many good attempts are being made globally to do away with energy intensive buildings, it is disappointing to admit that energy intensive buildings are very much fashionable in Kenya today and are still on our architects' drawing boards.

These include:

1. The glass-cladded high-rise buildings in our cities which rely on air-conditioning and mechanical ventilation during daytime and artificial heating at night. In tropical climates, these buildings are essentially solar furnaces and to maintain their internal microclimate within human thermal comfort levels, refrigeration or air conditioning is required. They contribute high emission of CO_2 as well as other greenhouse gases thus accelerating the rate of global warming.
2. The Deep plan buildings which rely on artificial lighting, air-conditioning and mechanical ventilation.
3. High embodied energy buildings with their sleek looking imported construction materials and imported fittings and appliances.

Buildings in Nairobi
25 YEARS AGO

Some new buildings in Nairobi TODAY

CBK Pension towers

The Prism Tower

One Africa Place

Environmentally Conscious Buildings in Nairobi between 1960 and 1980s

Environmentally Conscious Buildings in Nairobi TODAY

Since the mid 1980's, booming towns in East Africa have been cursed with the dreadful imitations of the glass building which was originally developed in the temperate climates of the northern hemisphere, in particular Europe and North America and today, we continue to witness the indiscriminate importation of this air-conditioned glass building into the East Africa towns. The situation is true for most cities or towns within tropical climates.

Our central business districts are characterised by these homogeneous symbols of corporatism and extravagance, even with our hot climates.

The glass cladded building was said to be suitable to the temperate climate found in London, New York and Chicago, BUT this is no longer the case! There is wind of CHANGE in the Cold Climates. This glass cladded building, when did it also become suitable for the tropical climate cities e.g. Nairobi, Mombasa, Kisumu, Dar-es-salaam and Kampala, if it is being rejected in Europe and America?

The glass cladded buildings are now proving to be uneconomical even in Europe, and the cooling loads they generate in the tropics are ridiculously wasteful. Why must we build these glass furnaces in our towns?

How Rafael Vinoly's 'Walkie Talkie' Skyscraper in London melts a Jaguar Car

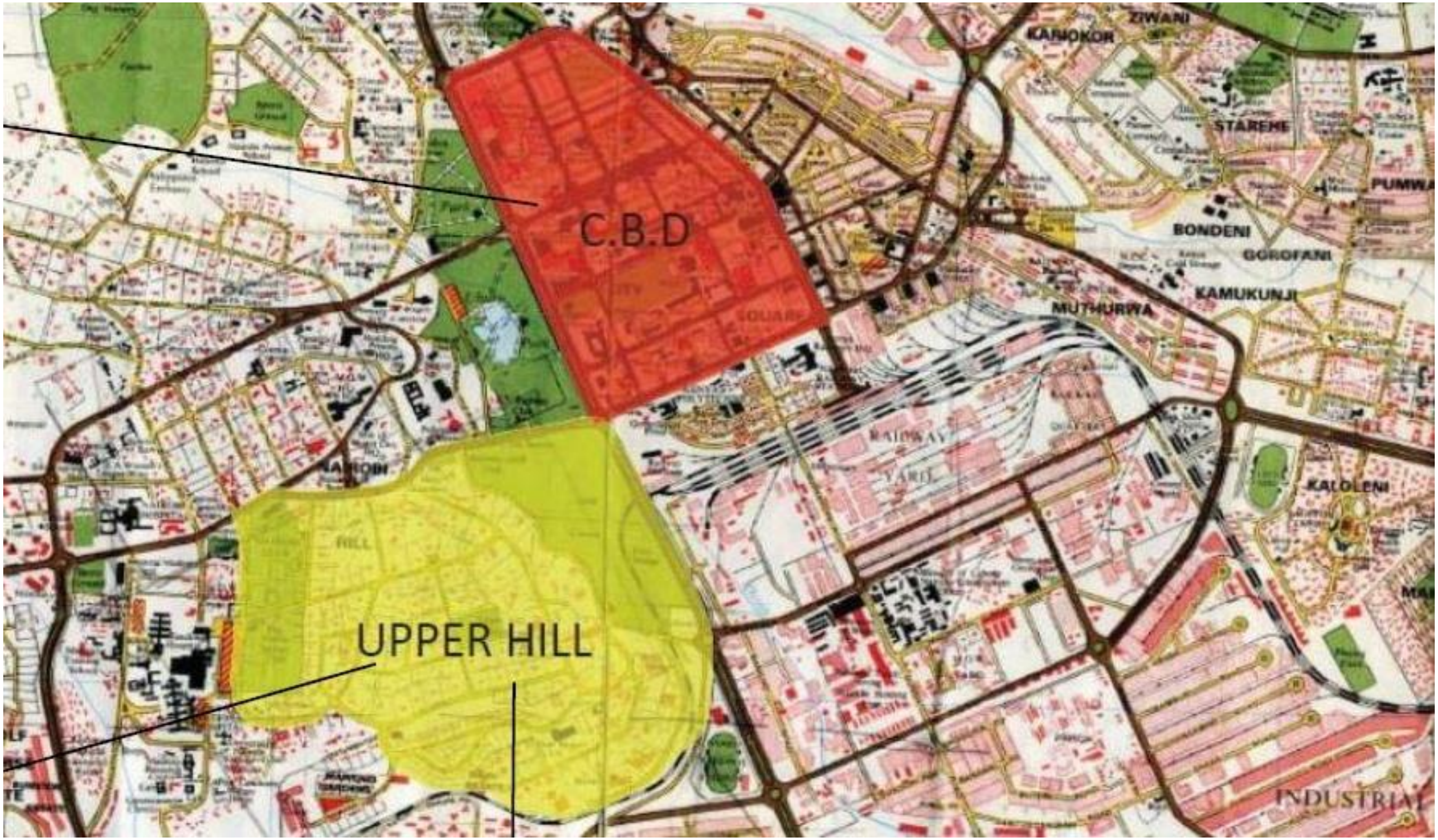
2nd Sept 2013

Today, what we need is a new generation of buildings: Low in energy consumption and environmentally friendly, that will set new standards in our cities. Hence in our case, we must put up buildings that are suitable to the tropical climates.

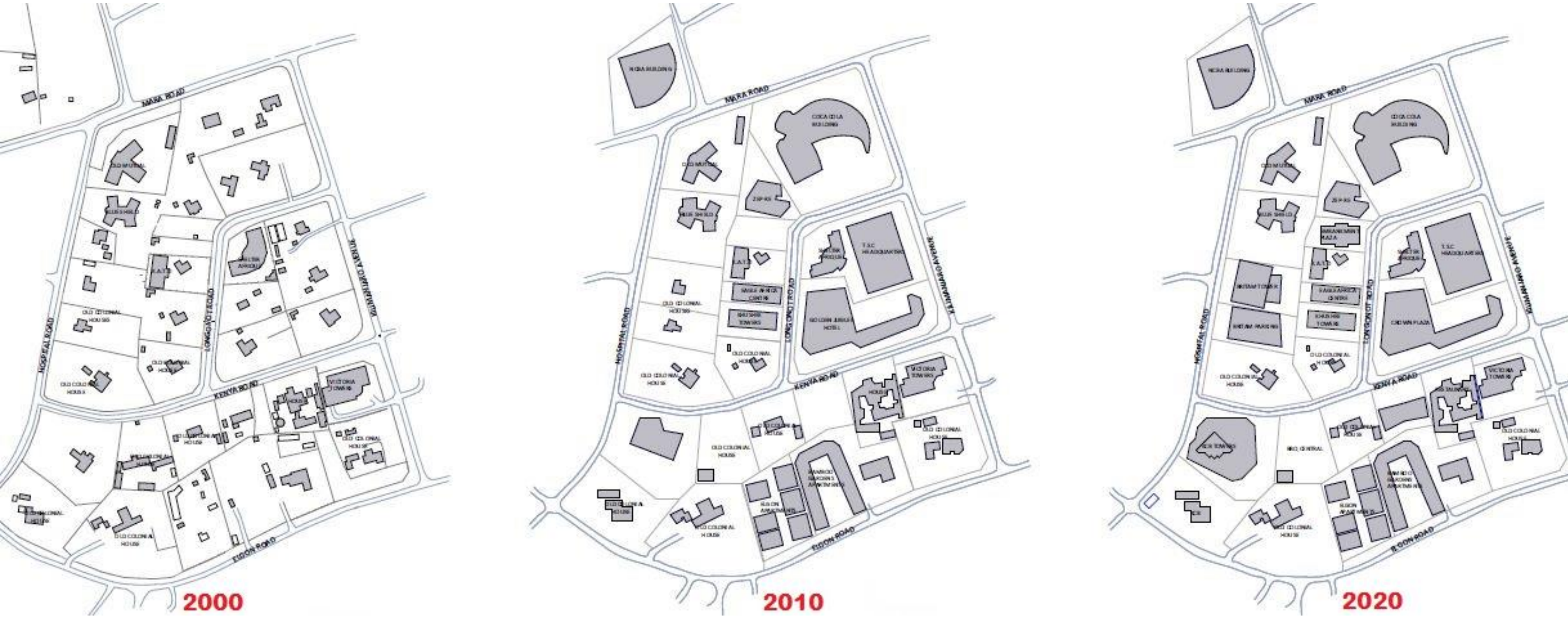
Remember that despite the lack of training and technology, our ancestors instinctively knew how to engage on a symbiotic dialogue with the natural forces of the environment and as a result we found the environment in good condition.

Let us guarantee our grandchildren and future generations the opportunity to live in an environment capable of supporting their needs by designing and putting up sustainable buildings.

5.0 FIELDWORK & ANALYSIS
A CASE STUDY OF UPPERHILL, NAIROBI

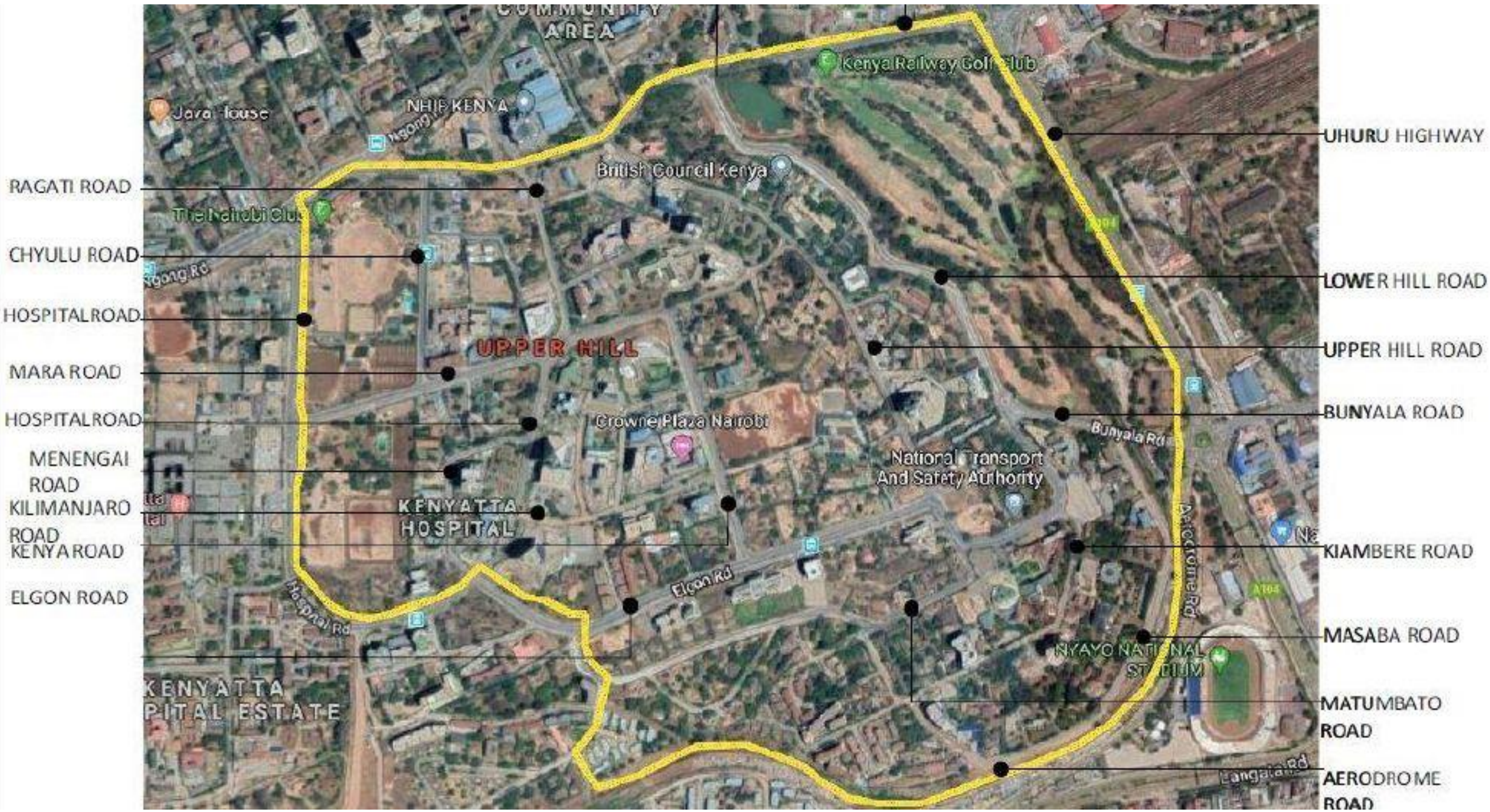


Nairobi's CBD and Upperhill area highlighted



Construction growth of Upperhill area in the last Twenty (20) years

Upperhill, Nairobi in 2010



Upperhil, Nairobi in 2020

GLOBAL WARMING POTENTIAL:
A CASE STUDY OF UPPER HILL, NAIROBI

To demonstrate the impact of buildings on Climate Change, we carried out two field studies in the Upper Hill area of Nairobi spaced ten (10) years apart. The first field study was undertaken in 2009 and 2010 and the second in 2019 and 2020.

A) FIELD STUDY OF 2009 -2010

Five newly completed neighbouring buildings, all located in Nairobi's Upper Hill area were selected for computation of their Carbon footprint. The buildings included Blueshield building, Geminia Insurance building, Shelter Afrique, Old-Mutual and Coca-Cola headquarters. The research was undertaken from October 2009 to April 2010.

1. **The criteria for their selection included the fact that they house similar activities, they are neighbouring buildings and hence receive similar solar radiation intensities and all were recently built.**

The FIVE BUILDINGS varied in terms of their built form configuration, facade design, external finishes, day lighting and ventilation strategies used.

Two of the buildings are glass cladded high-rise buildings namely Geminia Insuarance and Blue-shield buildings, whereas one is fully environmentally conscious namely, the Coca-Cola headquarters. The other two buildings i.e shelter Afrique and Old-Mutual buildings fall in between the two extremes.

Both internal and outdoor temperature and relative humidity measurements were logged during the hot months of October and early November 2009 and in January, February and March 2010. In addition physical analysis of each building was undertaken. Each building's embodied and operational energy were calculated and analysed.

For each building, the following parameters were studied:

1. Physical analysis
   i. Built form configuration – Floor plate/plinth, shape, orientation in relationship to sun movement
   ii. Façade design
   iii. Solar control devices
   iv. Day lighting strategies
   v. Ventilation strategies

2. Internal and External Temperature and relative humidity analysis using computer programmed data loggers

3. Building materials investigation

   This included: Building elements such as floors, walls, columns, beams, doors, windows, roof, all construction materials including finishes etc and their surface areas.

   From these calculations, each building's total embodied energy impact was established.

3. Operational energy Climate Change impact of each building

For each building, the total number of air-conditioning units installed and their sizes was established. This information was used to calculate the Annual Environmental Impact of the air-conditioning units by establishing the Total CO_2 emitted from the units per year.

In addition, the Total CO_2 emitted by any generators installed in the building per year was also established.

The sum total of these two gave us the TOTAL CLIMATE CHANGE IMPACT of the building.

4. With the above information, Comparative analysis of the five buildings was undertaken and lessons and conclusions drawn.

   The Comparative analysis included the following:

   i. The buildings physical analysis
   ii. Indoor temperature
   iii. Embodied energy Impact
   iv. Operational energy impact

Selected buildings:

Five neighbouring buildings were selected for Computation of their carbon footprint namely:

- **Old-Mutual building**
- **Shelter Afrique**
- **Coca-Cola Headquarters**
- **Blue-shield building.**
- **Geminia Insurance building**

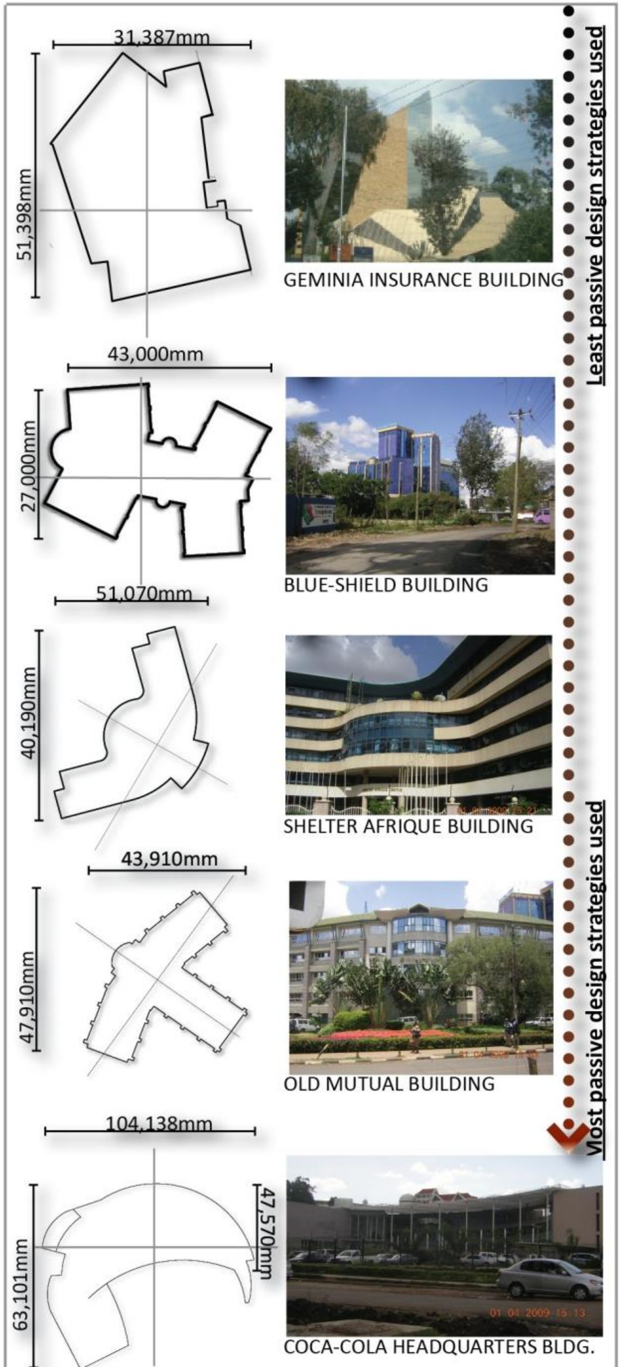
BLUE SHIELD BUILDING

SHELTER AFRIQUE

OLD MUTUAL BUILDING

COCA COLA HEADQUARTERS

GEMINIA INSURANCE BUILDING



5.1 Physical Analysis

Of the five buildings investigated, the results were as follows:

1. **Coca Cola headquarters building has the best passive design strategies used to achieve human thermal comfort levels compared to the rest, followed by Old Mutual building, Shelter Afrique, Blue shield and lastly Geminia building in that order as illustrated.**

2. **In addition, Coca cola headquarters building has the lowest level of consumption of energy from non-renewable resources and also the lowest greenhouse gas emissions.**

5.2 Embodied Energy Calculations

BUILDINGS	Primary Energy (MMBtu)	Global Warm-ing Potential (tons)	Weighted Re-source Use (tons)	Air Pollution Index	Water Pollu-tion Index	Area of the site (ha)	Footprint area (m^2)	Global Warm-ing Potential per footprint area (tons/m^2)
GEMINIA	319627	25372	135598	3843375	11446.81	0.38	1317	19.26
BLUESHIELD	44919	4122	18457	713646	51249.81	0.36	986	4.18
SHELTER AFRIQUE	35107	2789	12453	518479	976.45	0.32	947	2.95
OLD MUTUAL	31369	2648	11593	477542	27783.20	0.31	934	2.84
COCA-COLA HQ.	48651	4200	22423	705402	1300.57	1.63	3969	1.05

From the embodied energy, Carbon emission potential analysis carried out, of the five Case Study buildings, Geminia Insurance building recorded the highest Global Warming potential at 19.26 tonnes per square metre of the built area compared to Coca–Cola Headquarters building which recorded the least Global warming potential of 1.05 tonnes per square metre of the built area.

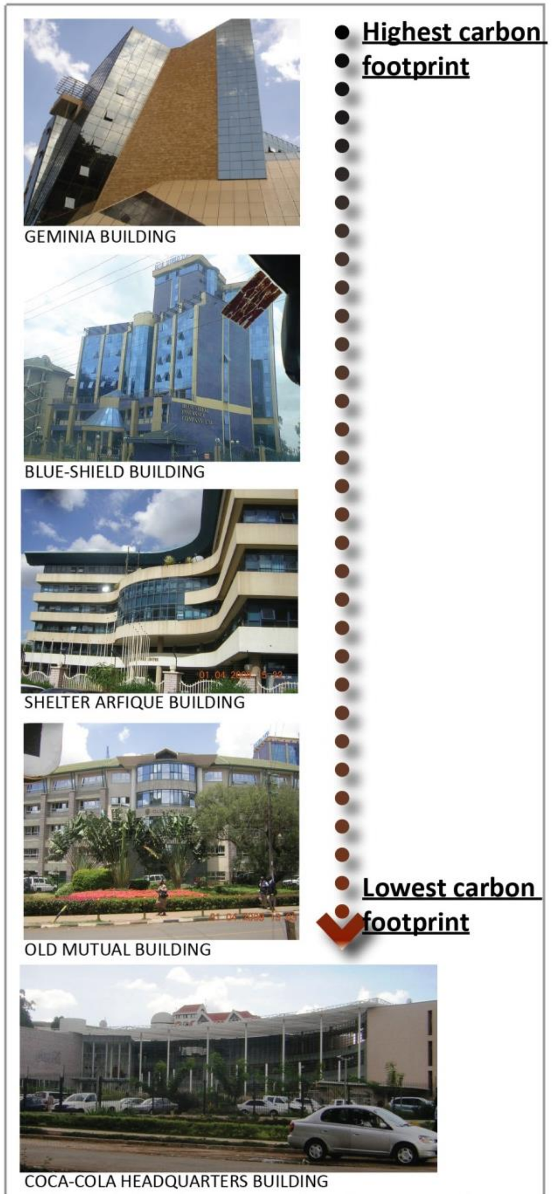
5.3 Operational Energy

BUILDINGS	No. of air conditioners serving the building	Litres of diesel used by generator in 2009 (l)	pounds of CO_2 produced from air conditioners in 2009 (lbs)	pounds of CO_2 produced by power generator in 2009(lbs)	total tonnes of CO_2 produced by operational energy in 2009 (tons)	Area of the site (ha)	Footprint area (m^2)	CO_2 produced by operational energy per footprint area (tonnes/m^2)
GEMINIA	71	23,986	238.44	19,277.00	8.78	0.38	1317	0.006
BLUESHIELD	3	156,428	10.07	125,720.41	56.59	0.36	986	0.057
SHELTER AFRIQUE	10	10,429	33.59	8,381.69	3.79	0.32	947	0.004
OLD MUTUAL	25	26,071	83.96	20,952.99	9.47	0.31	934	0.010
COCA-COLA HQ.	72	11,600	241.80	9,322.71	4.30	1.63	3969	0.001

Table 5.52: Comparative analysis of the Total operational energy impacts of the five case study buildings as analysed earlier

From the Comparative Analysis of Operational Energy undertaken for the five buildings, Blueshield Insurance building takes the lead with the highest recorded tonnes of Carbon dioxide (CO2) per square metre of the built area of 0.057 tonnes per square metre as it recorded the highest consumption of diesel (fuel) used by its power generator in 2009, followed by Old Mutual Insurance building at 0.01 tonnes per square metre. Geminia Insurance building follows at 0.006 tonnes per square metre and Shelter Afrique at 0.004 tonnes per square metre. Coca-Cola headquarters building recorded the least Carbon dioxide (CO2) emission per square metre from its operational energy.

5.4 Total Climatic Impact



BUILDINGS	Global Warming Potential per footprint area (tons/m²)	CO_2 produced by operational energy per footprint area (tons/m²)	Total global warming potential per footprint area (tons/m²)
GEMINIA	19.26	0.006	19.266
BLUESHIELD	4.18	0.057	4.237
SHELTER AFRIQUE	2.95	0.004	2.954
OLD MUTUAL	2.84	0.010	2.850
COCA-COLA HQ.	1.05	0.001	1.051

Of the five case study buildings, Geminia insurance has the highest Carbon Footprint followed by Blueshield Insurance building, Shelter Afrique, Old Mutual building in that order with the least being Coca-Cola headquarters building which records 1.051 tonnes per square metre global warming potential.

From the results of this investigation, it is evident that buildings that incorporate the Principles of Climate Responsive design / Sustainable design which are discussed in this paper are the least polluters of the environment whereas buildings that are insensitive to Climatic Design like Geminia Insurance and Blueshield amongst other similar glass cladded buildings are contributing significantly to Climate Change and thus damaging planet earth.

It is without doubt that all building activities involve use, redistribution and concentration of some component of the earth's energy and material resources that end up changing the ecology of the biosphere leading to the looming Climate Change disaster.

B) FIELD STUDY OF 2019 -2020

Six neighbouring buildings in Nairobi's Upper Hill area were selected for computation of their Carbon footprint. The buildings included the two better performing buildings included in the research undertaken ten (10) years earlier from October 2009 to April 2010, namely Old-Mutual and Coca-Cola headquarters.

In addition, four other buildings were added to the field study namely, Victoria Towers, KCB Towers, Embankment Plaza and NCBA building.

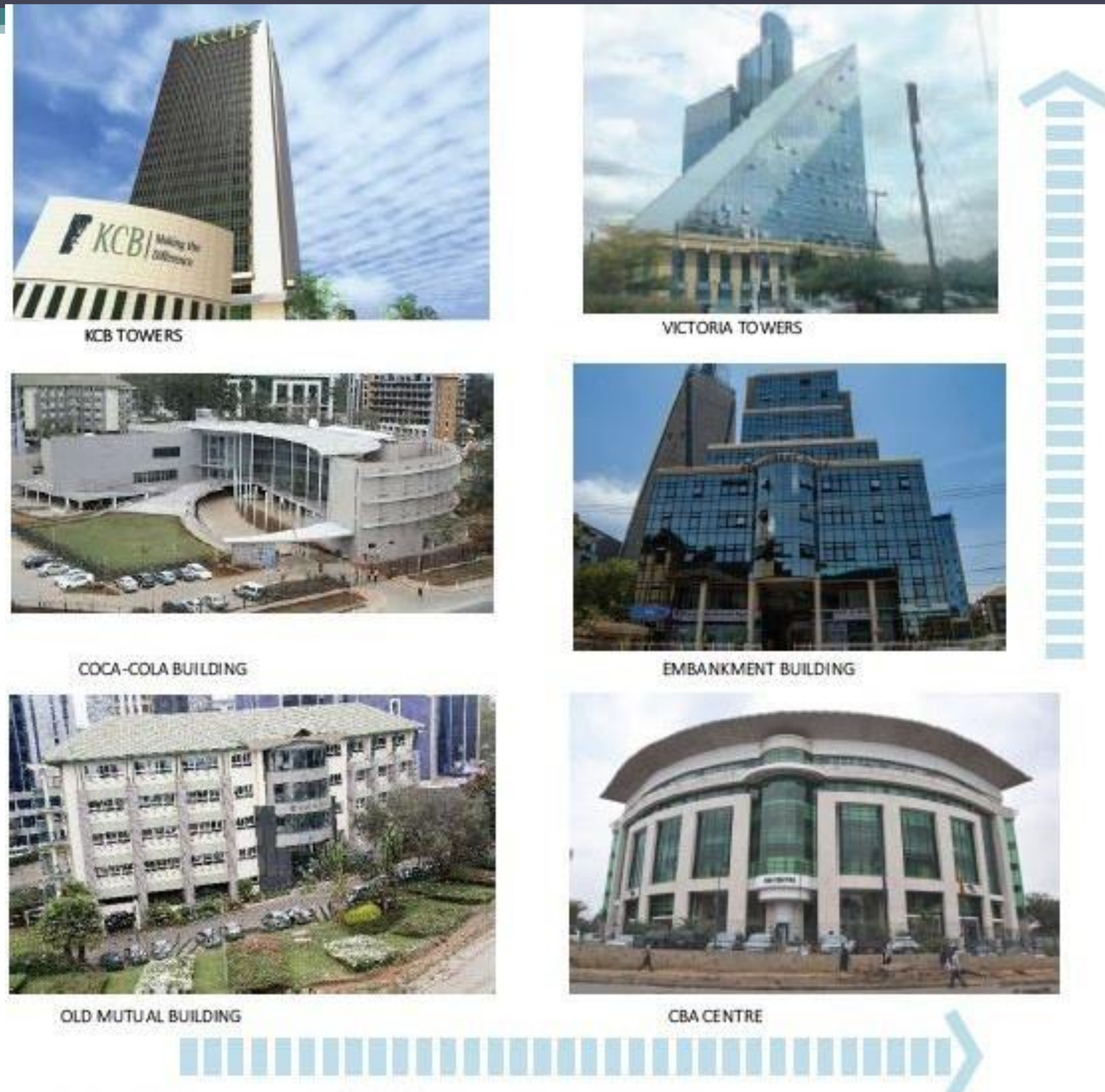
The same criteria for selection of the 2009 -2010 study was applied namely, they are neighbouring buildings and hence they receive similar solar radiation intensities and all were recently built.

For each building, exactly the same parameters undertaken in the buildings of 2009 – 2010 were studied.

The SIX BUILDINGS varied in terms of their built form configuration, facade design, external finishes, day lighting and ventilation strategies used.

Two of the buildings are fully glass cladded high-rise buildings namely Embankment Plaza and Victoria Towers, whereas one is fully environmentally conscious namely the former Coca-Cola headquarters. The other three buildings i.e NCBA building, KCB Towers and Old-Mutual buildings fall in between the two extremes.

Both internal and outdoor temperature and relative humidity measurements were logged during the hot months of October and early November 2019. In addition physical analysis of each building was undertaken. Each building's embodied and operational energy were calculated and analysed and the results are as follows:



ORDER OF BUILDINGS WITH INCREASE IN GLAZED AREAS

5.5 Embodied Energy

BUILDINGS	Fossil Fuel Consumption (MJ)	Global Warming Potential (kg CO2 eq)	Acidification Potential (moles of H + eq)	HH Criteria (g PM10 eq)	Eutrophication Potential (mg N eq)	Ozone Depletion Potential (mg CFC – 11 eq)	Smog Potential (g o3 eq)	Footprint area (m2)	Global Warming Potential per footprint area (kg CO2 eq /m2)
KCB TOWERS	105,290,892	10,001	3,866,849	81,768	4,895,416	48,818	1,061,405	7105.6	1.41
EMBANKMENT	35,385,385	3,138	1,211,401	20,798	1,991,045	15,037	325,907	1200	2.61
VICTORIA TOWERS	31,973,190	2,916	1,136,839	21,451	1,948,722	14,667	305,747	1476	1.98
NCBA BUILDING	24,411,904	2,028	847,509	12,353	928,967	10,391	202,562	2240	0.91
OLD MUTUAL	40,655,543	3,489	1,417,326	19,109	1,560,228	20,514	330,171	31369	0.11
COCA COLA HQ.	36,853,746	3,125	1,116,671	16,242	1,518,194	15,780	317,944	48651	0.06

Embodied Energy Impact of the buildings

From the analysis, Embankment Plaza has the highest Global warming potential of 2.61 Kg CO_2 equivalent per square metre of built area compared to the former Coca-Cola headquarters building which has recorded the least Global warming potential at 0.06 Kg CO_2 equivalent per square metre of the built area.

The high figures from Embankment Plaza and Victoria Towers are attributed to the extensive use of glass cladding on the buildings facades.

5.6 Operational Energy

BUILDINGS	No of air-conditioning units	Litres of diesel used by generator in 2019	Pounds of CO_2 produced from AC in 2019	Pounds of CO_2 produced by pwr. gen. in 2019	Total ton. of CO_2 produced by Op. energy	Area of the Site (Ha.)	Footprint area (m^2)	CO_2 produced by operation energy per footprint area in kgs/m^2
KCB TOWERS	21	5000	70.5	29098.6	13.13		7105.6	0.185
EMBANKMENT	63	1200	211.58	964.43	0.529		1200	0.441
VICTORIA TOWERS	44	2000	147.77	1607.4	0.79		1476	0.535
NCBA BUILDING	33	375	110.83	301.29	0.185	0.79	2240	0.083
OLD MUTUAL	11	150	36.95	120.55	0.071	0.31	31369	0.002
COCA COLA HQ.	72	-	241.8	-	0.109	1.63	48651	0.002

From the Comparative Analysis of Operational Energy undertaken for the six buildings, Victoria Towers takes the lead with the highest recorded Carbon dioxide (CO_2) produced by operational energy per footprint area at 0.535 Kg per square metre followed by Embankment Plaza at 0.185 Kg per square metre. Both Old Mutual and the former Coca-Cola headquarters building recorded the least Carbon dioxide (CO_2) emission per square metre from their operational energy. These results are attributed to good passive design strategies employed, leading to a decline in the need for air-conditioning and use of a generator compared to the other buildings.

5.7 Total Carbon Dioxide emitted by each building

BUILDINGS	Global Warming Potential per footprint area (kg CO2 eq /m2)	CO_2 produced by operation energy per footprint area in kgs/m²	Total Global Warming Potential per footprint area (kg CO2 eq /m2)
KCB TOWERS	1.41	0.185	1.585
EMBANKMENT	2.61	0.441	3.051
VICTORIA TOWERS	1.98	0.535	2.515
NCBA BUILDING	0.91	0.083	0.993
OLD MUTUAL	0.11	0.002	0.112
COCA COLA HQ.	0.06	0.002	0.062

Of the Six case study buildings, Embankment Plaza has the highest Carbon Footprint of 3.051 Kg CO2 eq. per square metre followed closely by Victoria Towers, KCB Towers, NCBA building and Old Mutual in that order with the least being the former Coca-Cola headquarters building which records 0.062 Kg CO2 eq. per square metre.

From the results of the second investigation, it is evident that buildings that incorporate the Strategies of Climate Responsive design or Sustainable design are the least polluters of the environment whereas buildings that are insensitive to Climatic Design like Embankment Plaza and Victoria Towers amongst other similar glass cladded buildings are contributing significantly to Climate Change and thus damaging planet earth.

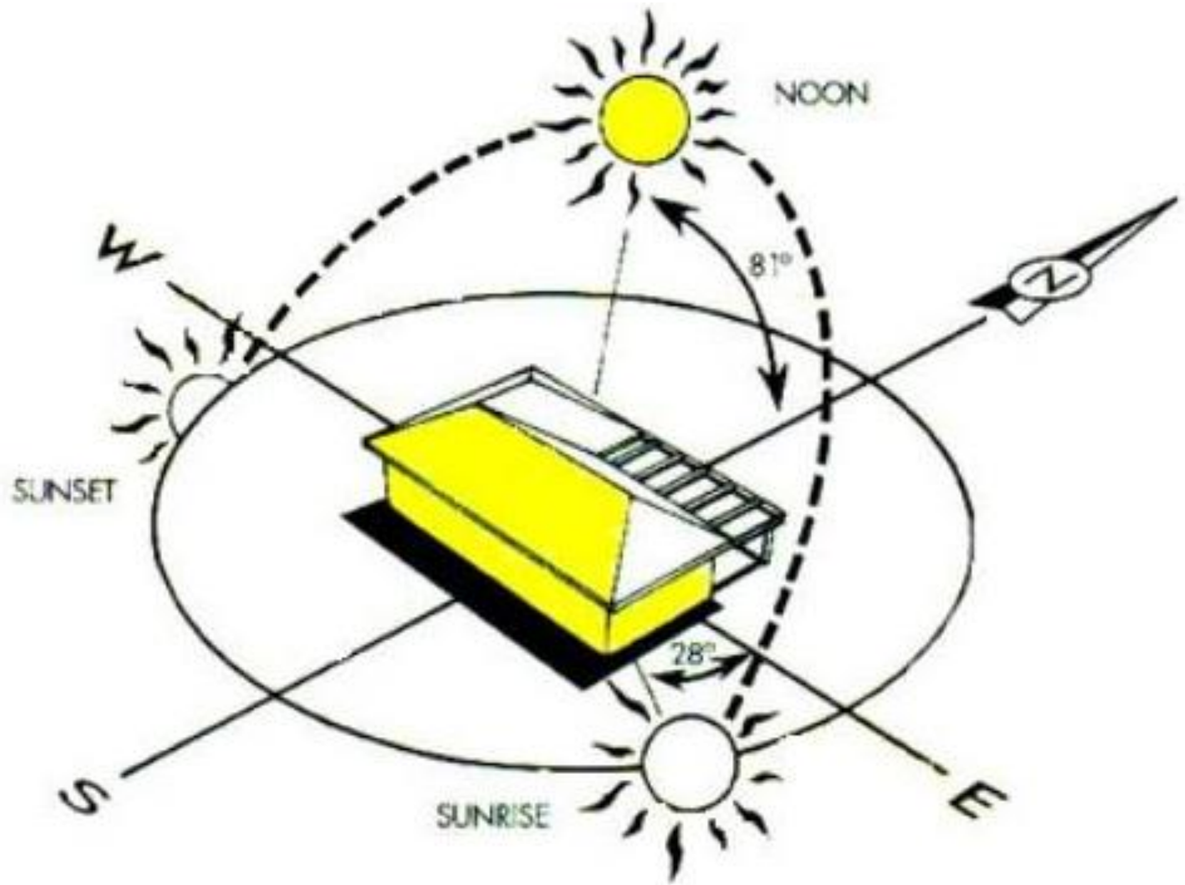
From the two investigations, it is evident that the glass-cladded high-rise buildings in our cities together with the Deep plan buildings and the high embodied energy buildings with their imported construction materials and imported fittings and appliances are heavily contributing to Climate Change whereas buildings that have incorporate Strategies of Climate Responsive design or Sustainable design are the least polluters.

6.0
SUSTAINABLE DESIGN STRATEGIES OR PRINCIPLES TO COMPACT CLIMATE CHANGE

PREVENTION OF HEAT GAIN and PROVISION OF COOLING STRATEGIES

1. **Buildings orientation:**

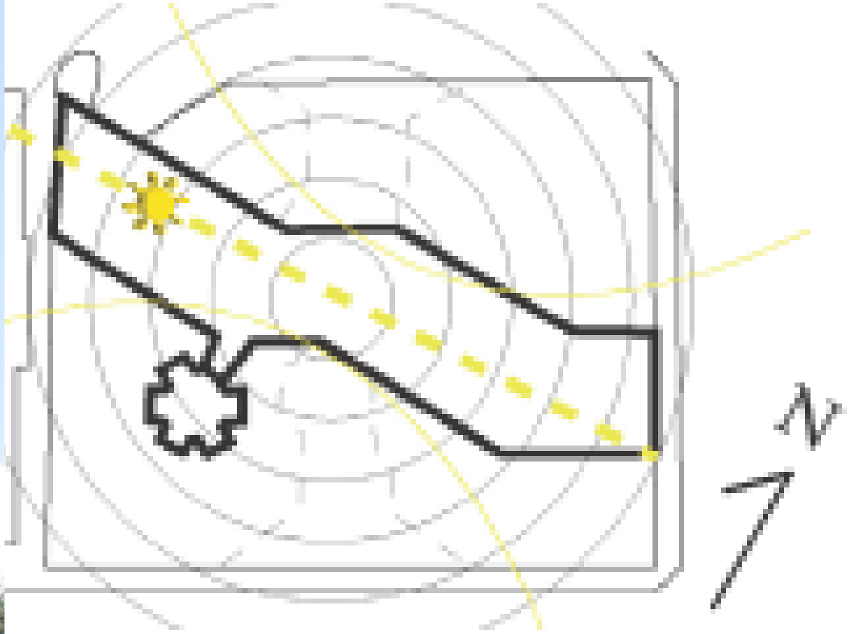
   Design your buildings such that the long axis is along the East-West axis



Buildings orientation
Long axis : East -West

Buildings orientation

Long axis : East - West

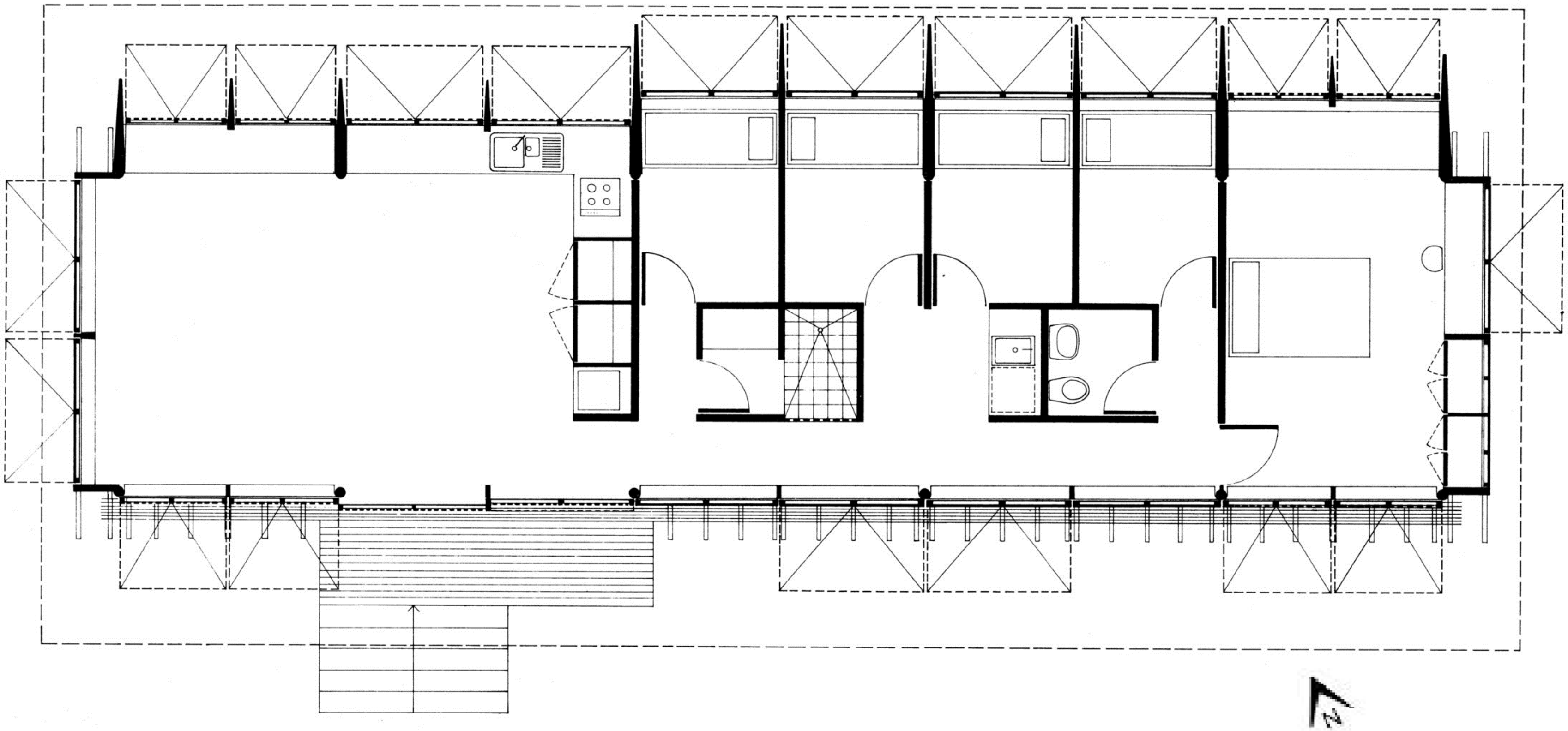


ICEA Building, Nairobi
Richard Hughes, 1980

PREVENTION OF HEAT GAIN and PROVISION OF COOLING STRATEGIES

2. Design buildings that are narrow in plan:

This helps to achieve maximum natural lighting penetration into the buildings and also good cross - ventilation



The Marika-Alderton House, Northern Territory, Australia Glenn Murcutt, 1994

3. Sun-shade all glazed areas

This should be realised by use of vertical and horizontal sun-shading elements, deep roof overhangs, balconies and perforated timber screens etc

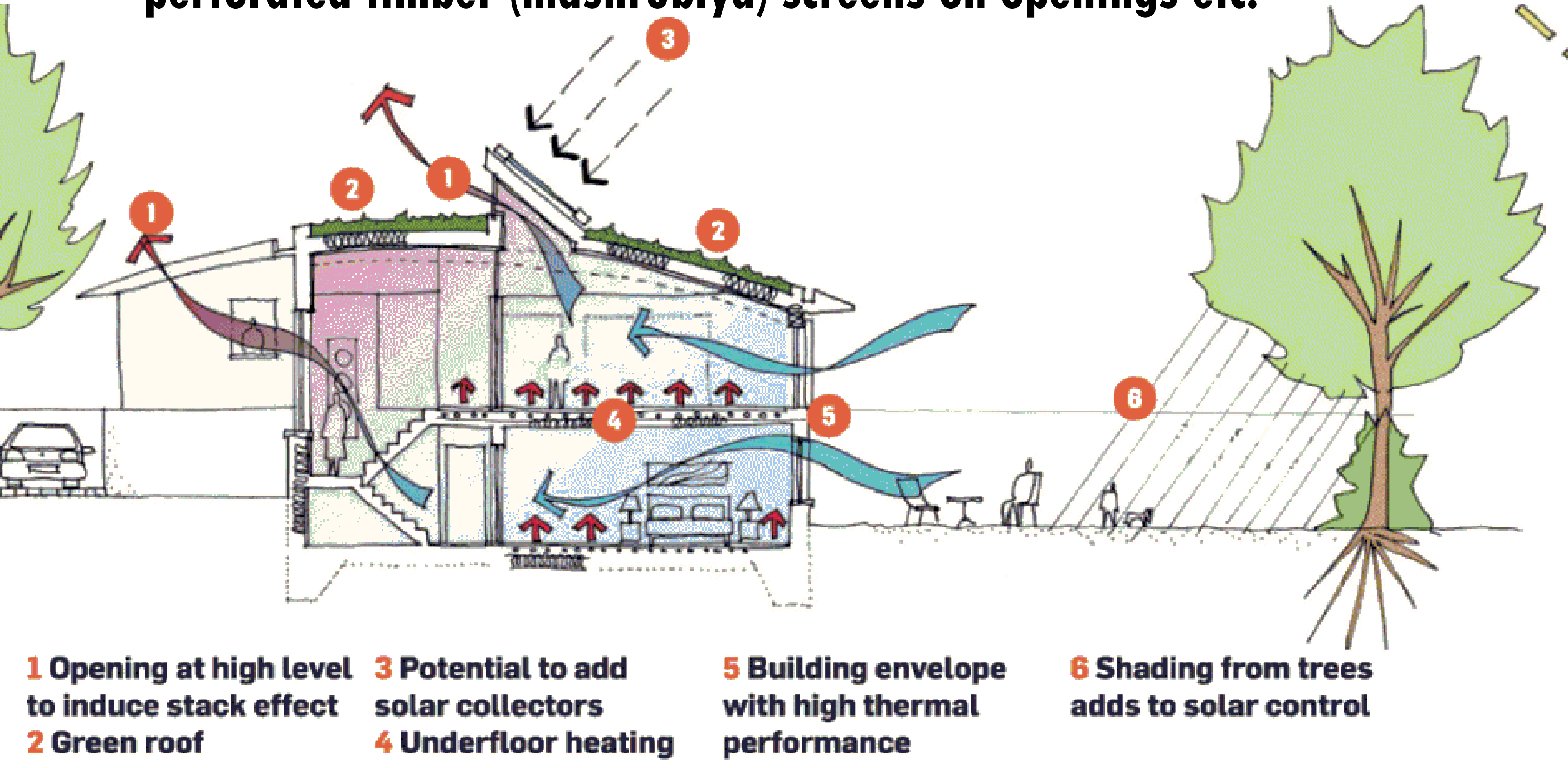
IPS building, Nairobi 1967

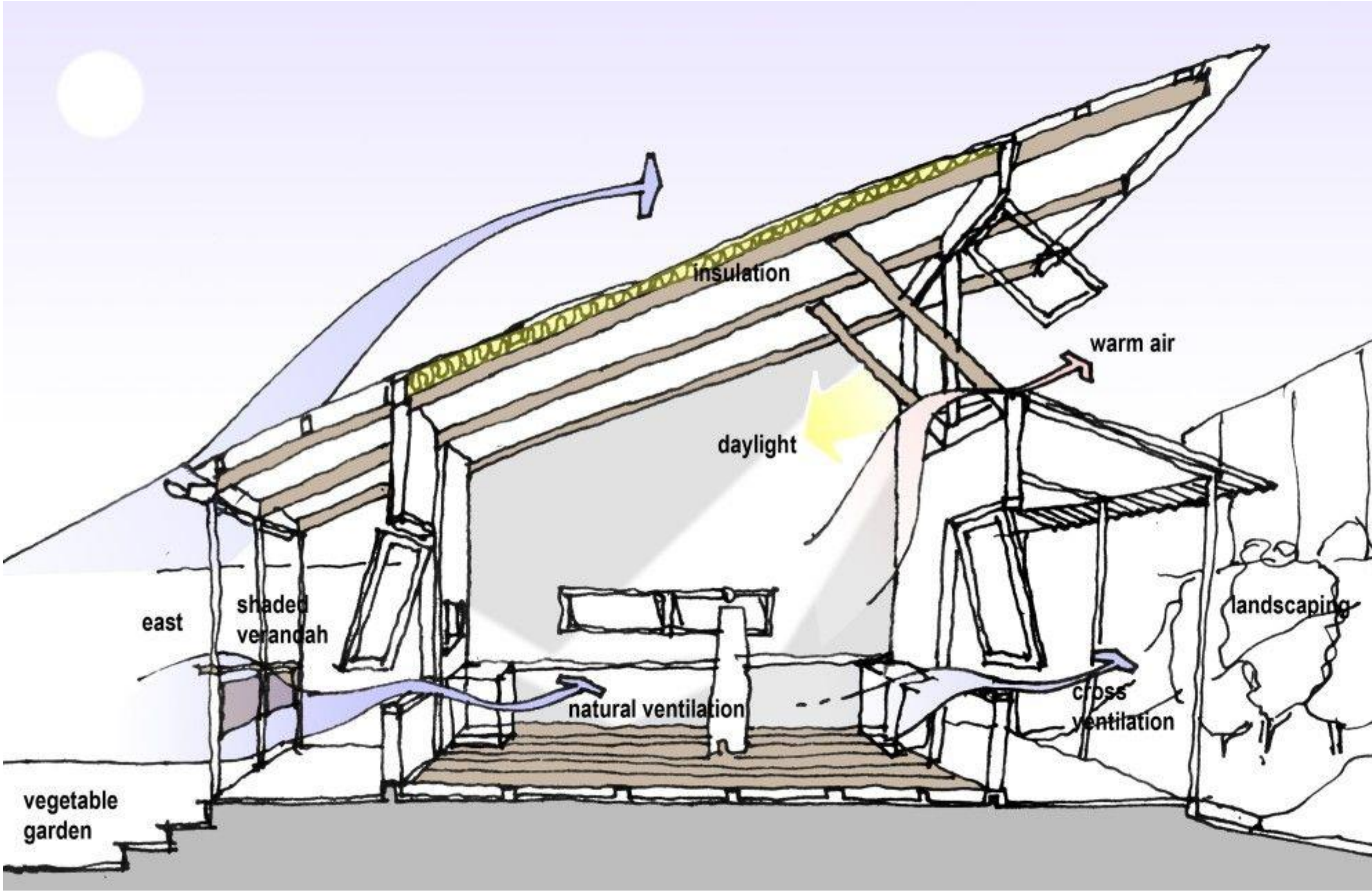
Architects - TAC

The Marika-Alderton House,
Northern Territory, Australia
Glenn Murcutt, 1994

4. Use natural ventilation to provide cooling:

This should be elaborately done throughout the building e.g. using operable windows, thermal chimneys, Wind chimneys (wind catchers/ wind scoop), metal/timber louvred fenestrations, perforated timber (mashrubiya) screens on openings etc.



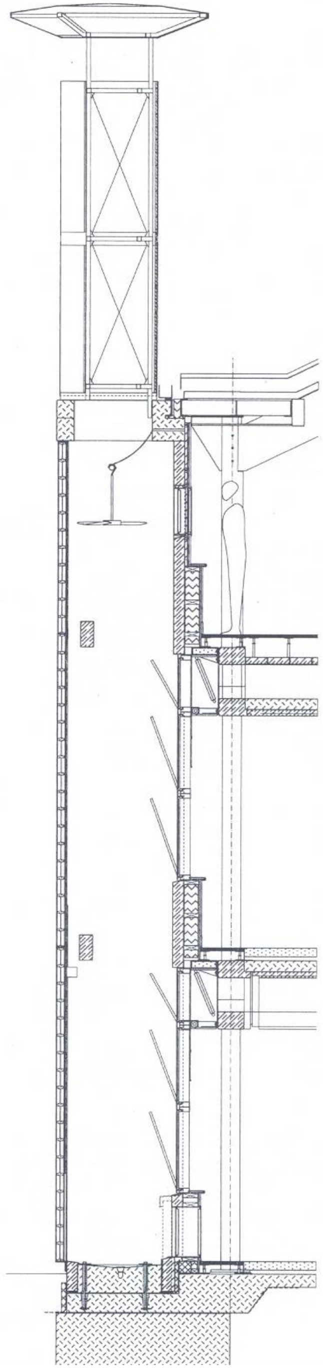


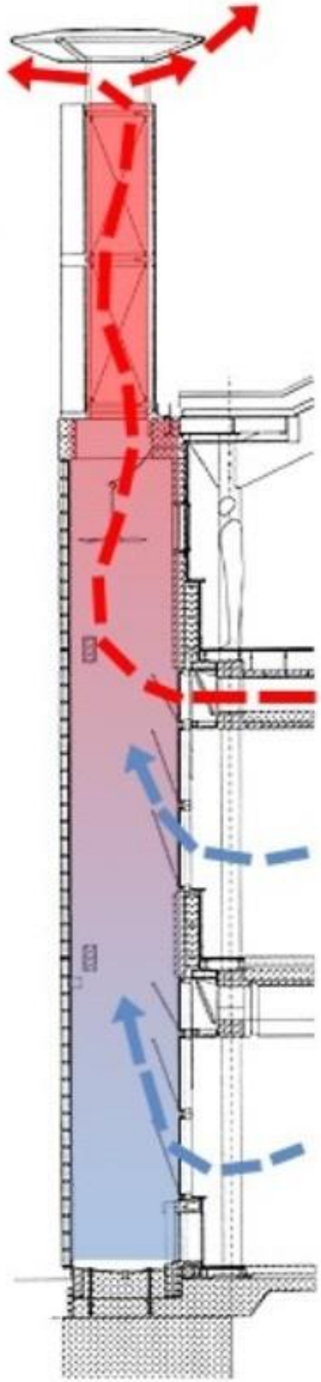
Cross Ventilation

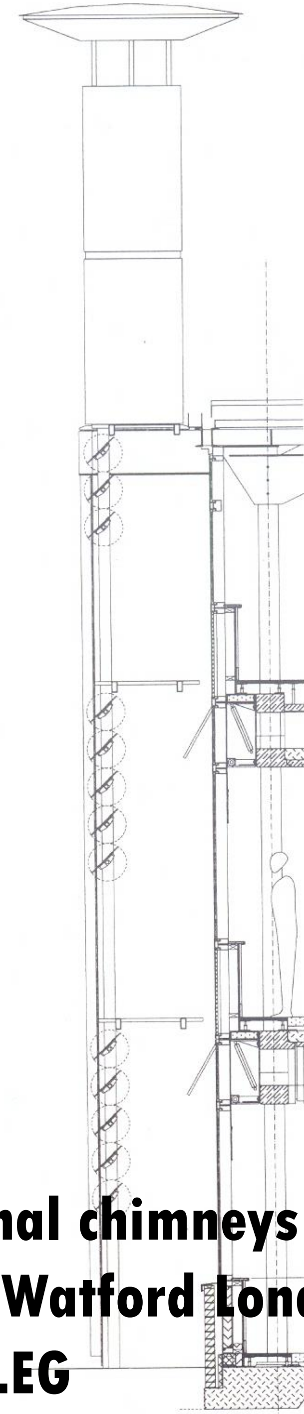
Traditional Wind chimneys (wind catcher/ wind scoop) in Yazd, Iran

Traditional Wind chimneys (wind catcher/ wind scoop) in Yazd, Iran

Modern thermal chimneys
BRE HEADQUARTERS, Watford London
Architects: FEILDEN CLEG

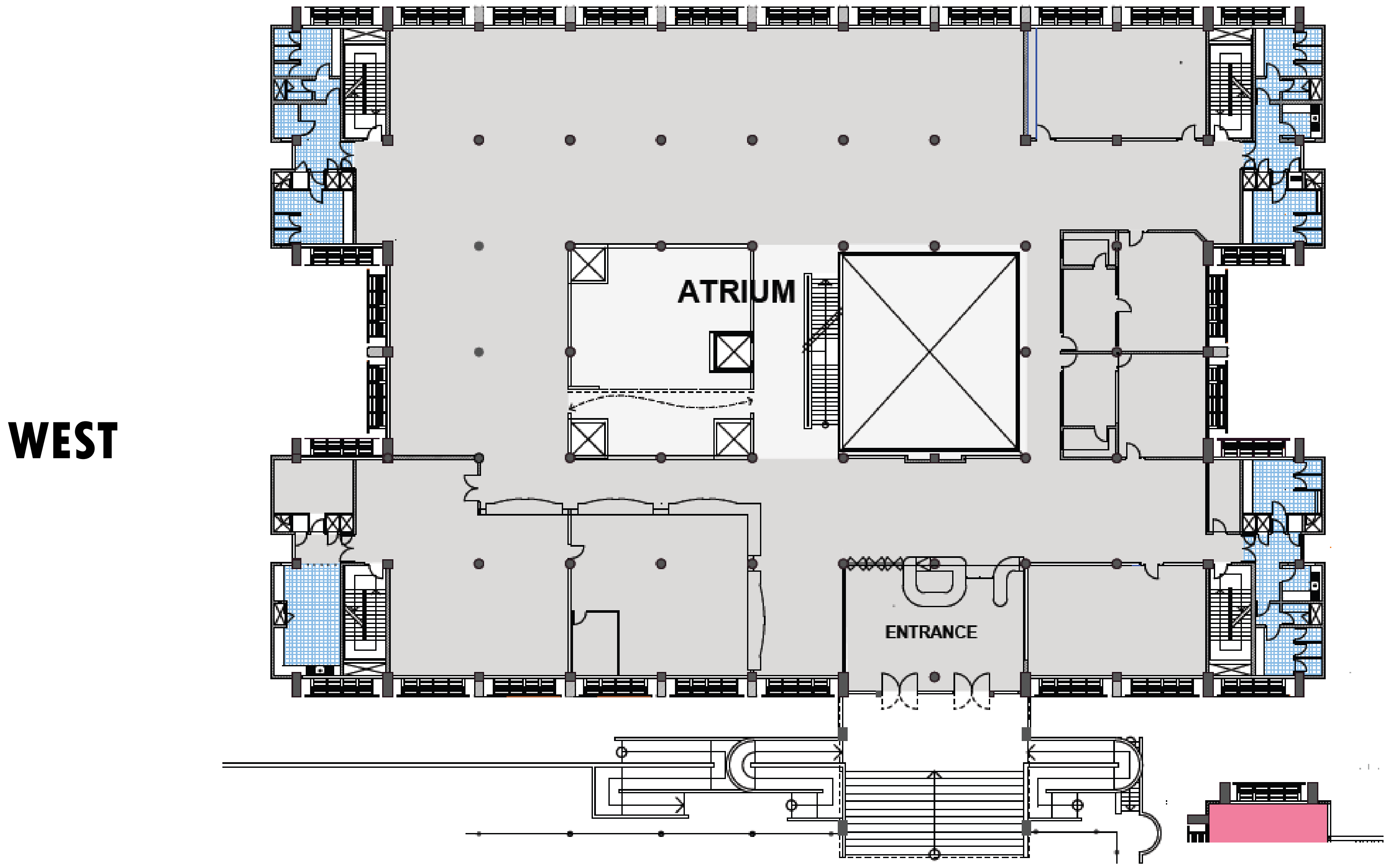






Section through thermal chimneys
BRE HEADQUARTERS, Watford London
Architects: FEILDEN CLEG

5. **Locate building services** (such as lifts, lobbies, toilets, stores, ducts etc) **on the East and West facing facades**



The LRC Library, CUEA
Musau Kimeu, 2012

Services placed EAST - WEST

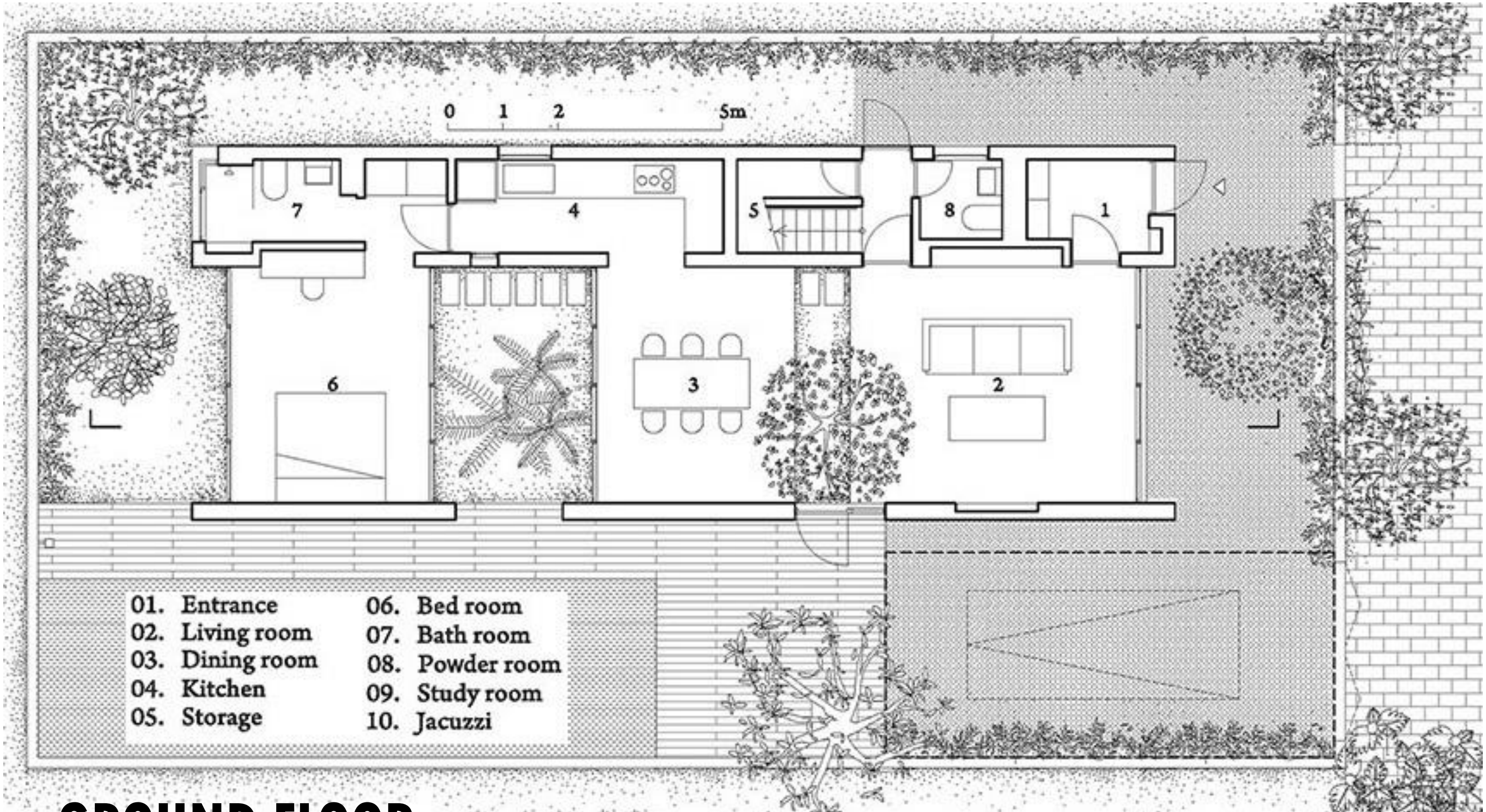
6. Have minimal window openings

It is recommended that all buildings located within the tropics, Kenya included should have minimal window openings.

Binh House - Vo Trong Nghia Architects (VTN Architects)

Binh House - VTN Architects
HO CHI MINH CITY, VIETNAM
2016

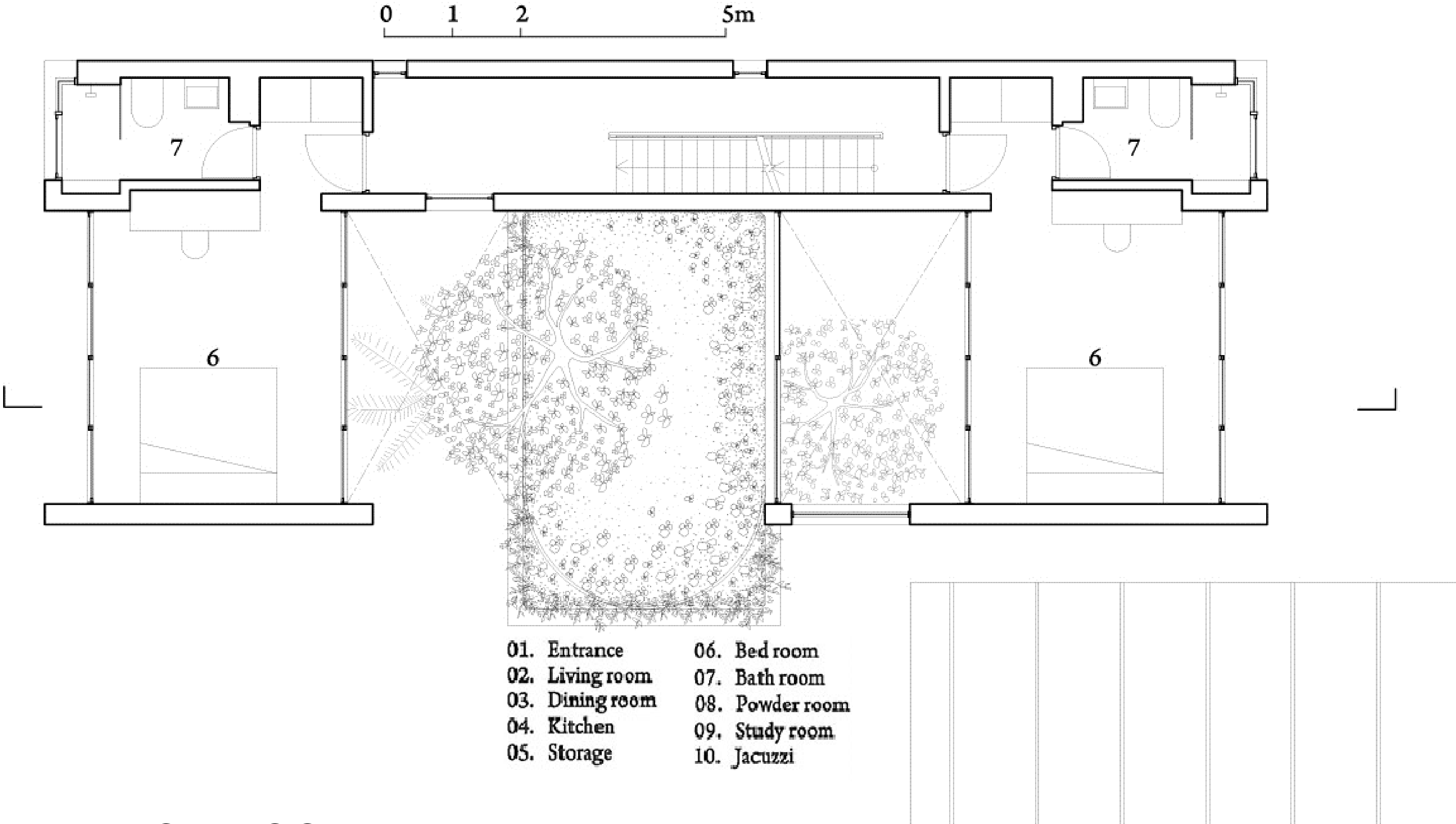
Area: 233 m²



GROUND FLOOR

Binh House 2016 - VTN Architects

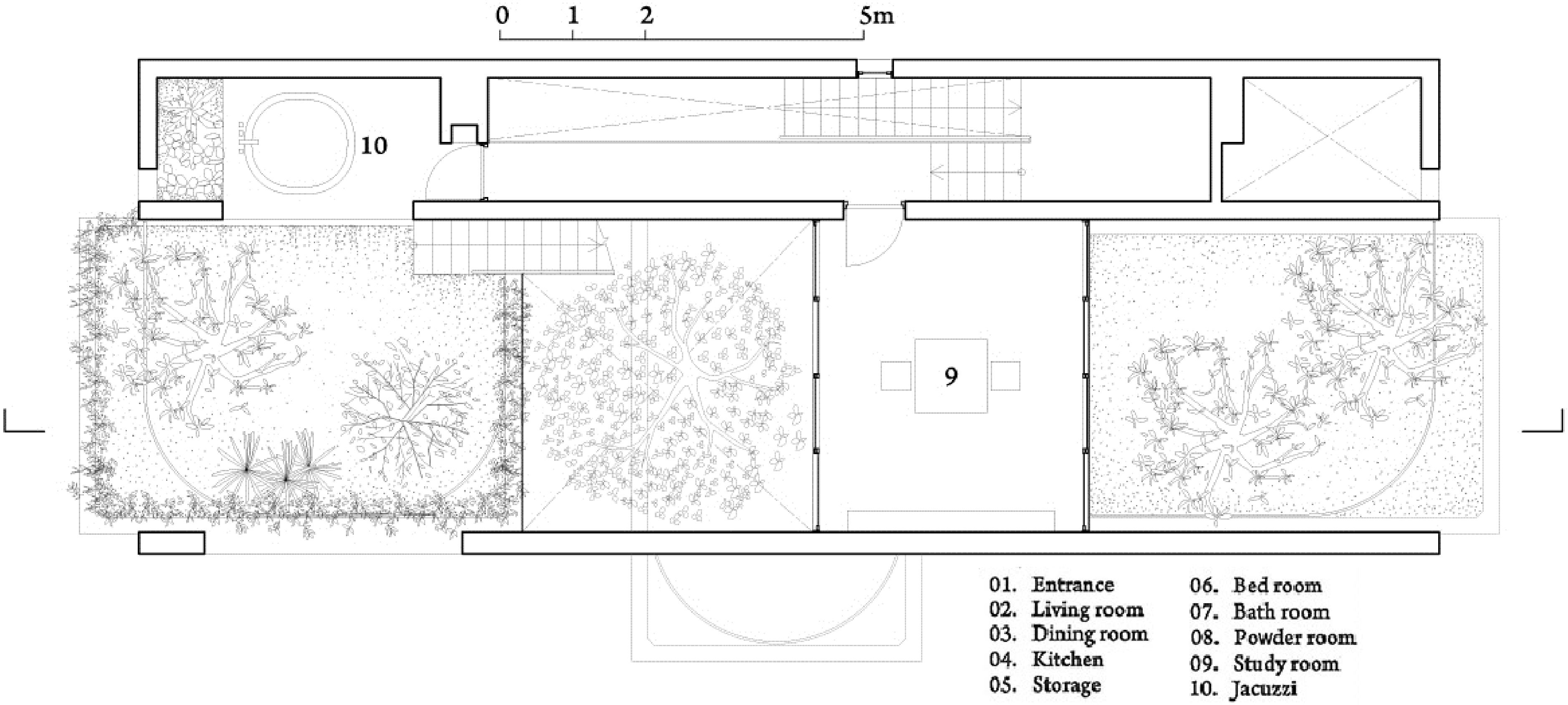
HO CHI MINH CITY, VIETNAM



FIRST FLOOR

Binh House 2016 - VTN Architects

HO CHI MINH CITY, VIETNAM



SECOND FLOOR

Binh House 2016 - VTN Architects

HO CHI MINH CITY, VIETNAM

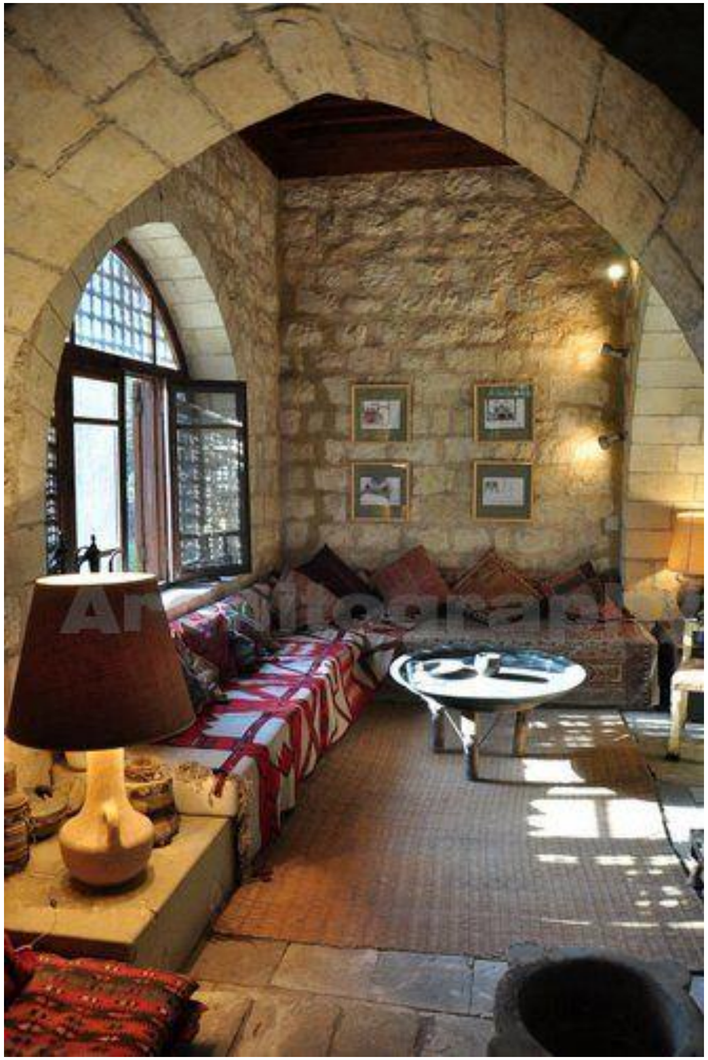
7. **Use external finishes that are smooth and light coloured to reduce solar heat absorption** e.g. roof cover consisting of brilliant white coloured external walls, g.c.i or aluminium-zinc sheets etc

Lamu Seafront: Smooth and Light coloured external finishes

Houses in Lamu :
Smooth and Light coloured finishes

8. Use high thermal mass on walls (thick walls)

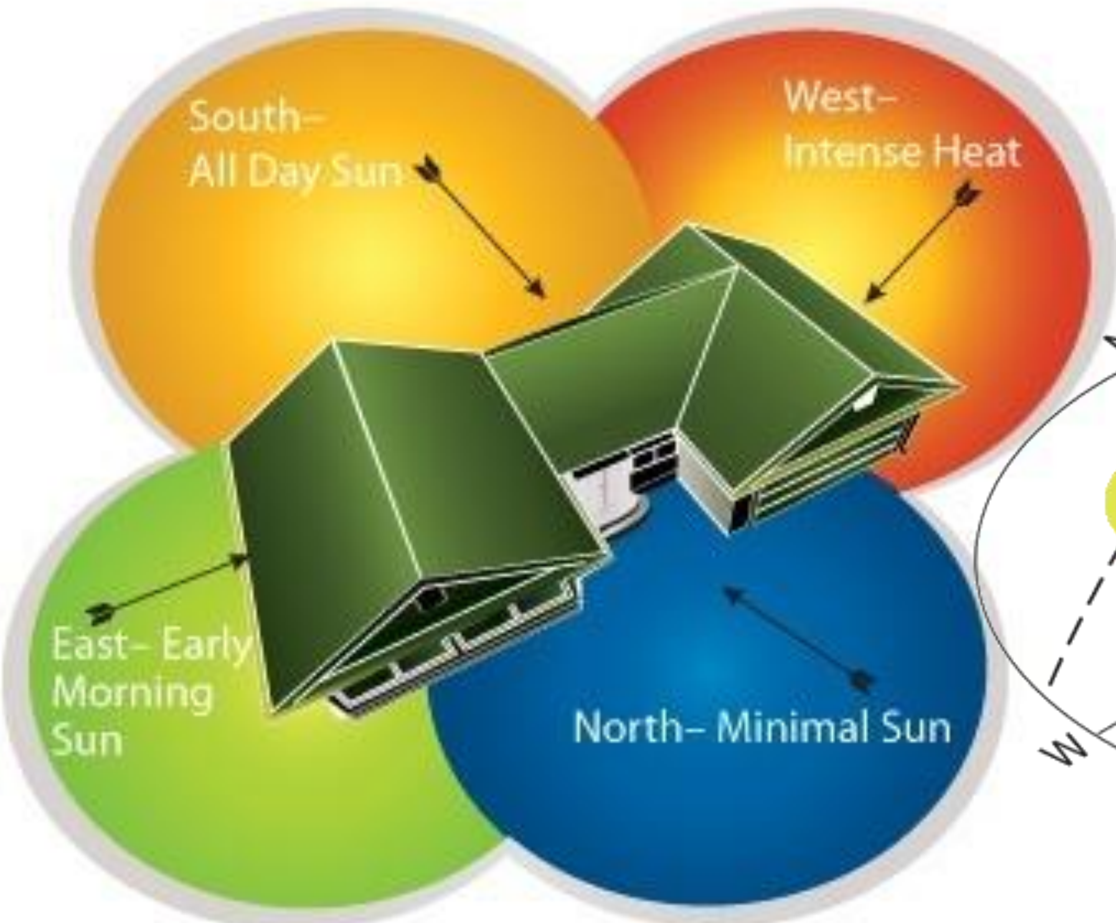
All external walls should be at least 200mm thick.

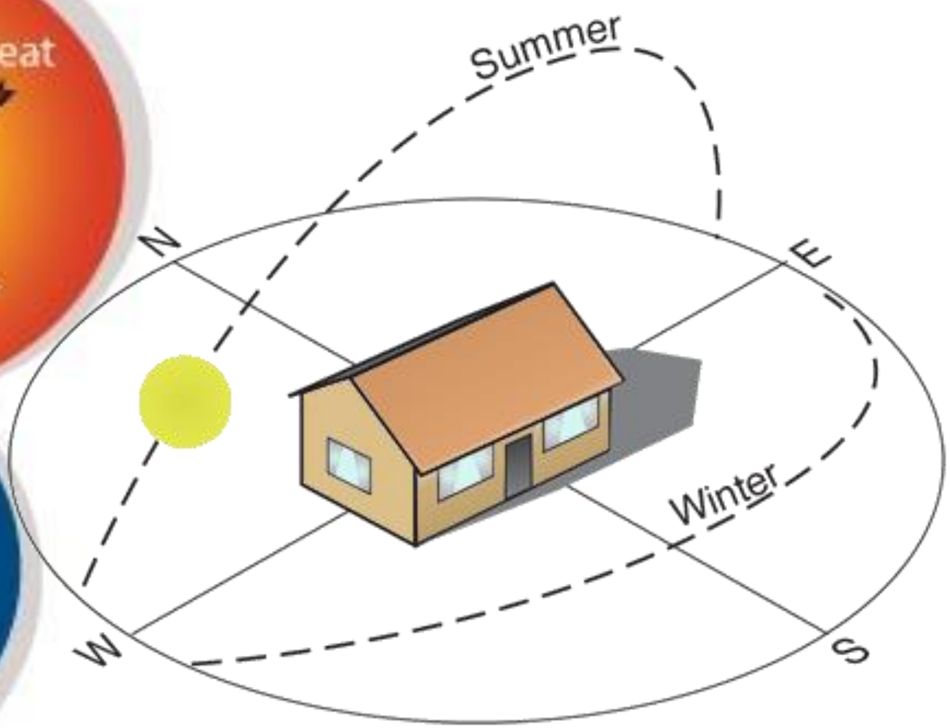


Hassan Fathy, Cairo Egypt

House in Lamu, Kenya

9. Place window openings on the North and South facing walls





10. CHOICE OF MATERIALS

Your building should use: Locally available materials, with low embodied energy, with none or minimal maintenance, materials that are sustainably harvested, non-toxic, those with minimal internal pollution and damage to health and those which are easy to re-cycle or to re-use

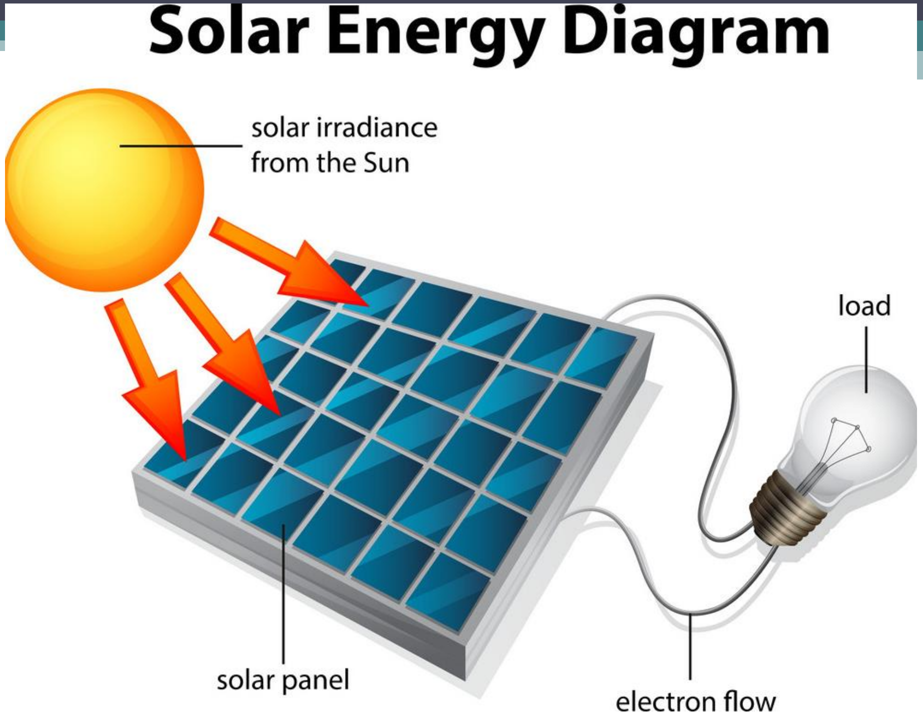
Locally sourced brick

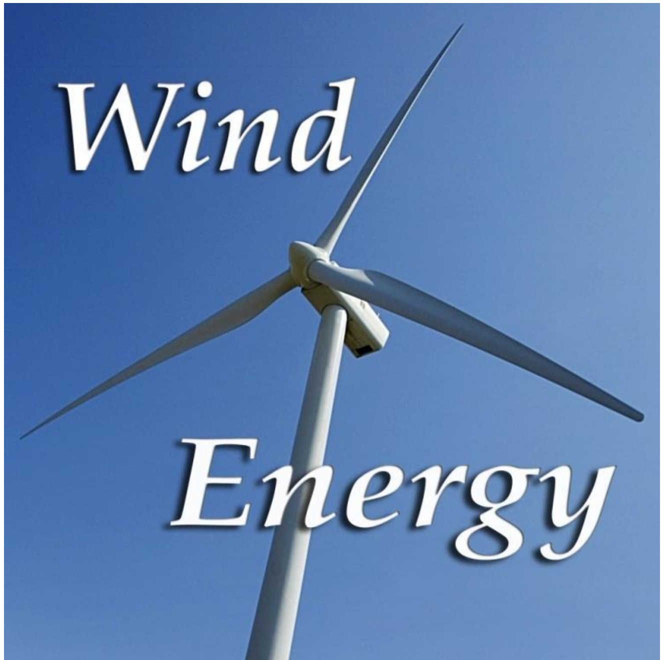
Hassan Fathy,
Cairo, Egypt

Coral stone wall,
Lamu, Kenya

11. RENEWABLE ENERGY

- Solar,
- Wind,
- Geothermal,
- Bio-fuels (Biogas etc),
- Hydro etc





1. SOLAR ENERGY:

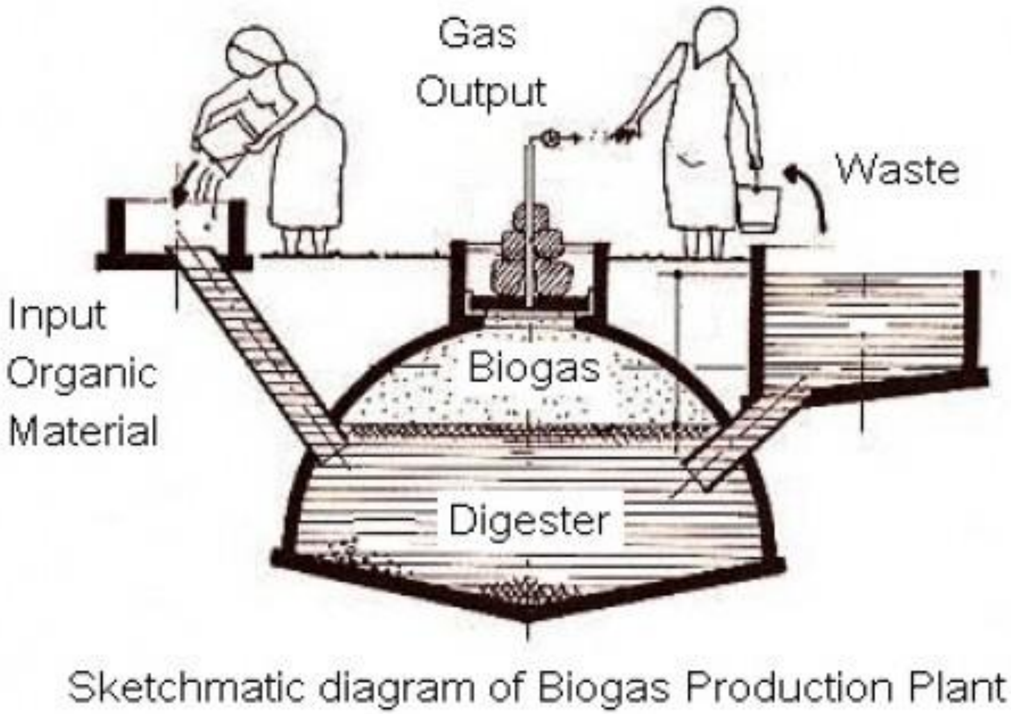
Solar power harvested using (1) Photovoltaic panels mounted on the ground or on the roof cover (2) Hot water solar heating panels.

Photovoltaic panels and Hot water solar heating panels

2. WIND ENERGY: Use wind energy to generate electricity

3. BIOGAS:

Use of biogas produced from the biodegradable waste generated within the project, especially projects in the outskirts of urban areas and rural based projects e.g. waste from farm produce and also from toilet waste



Bio-digester plant

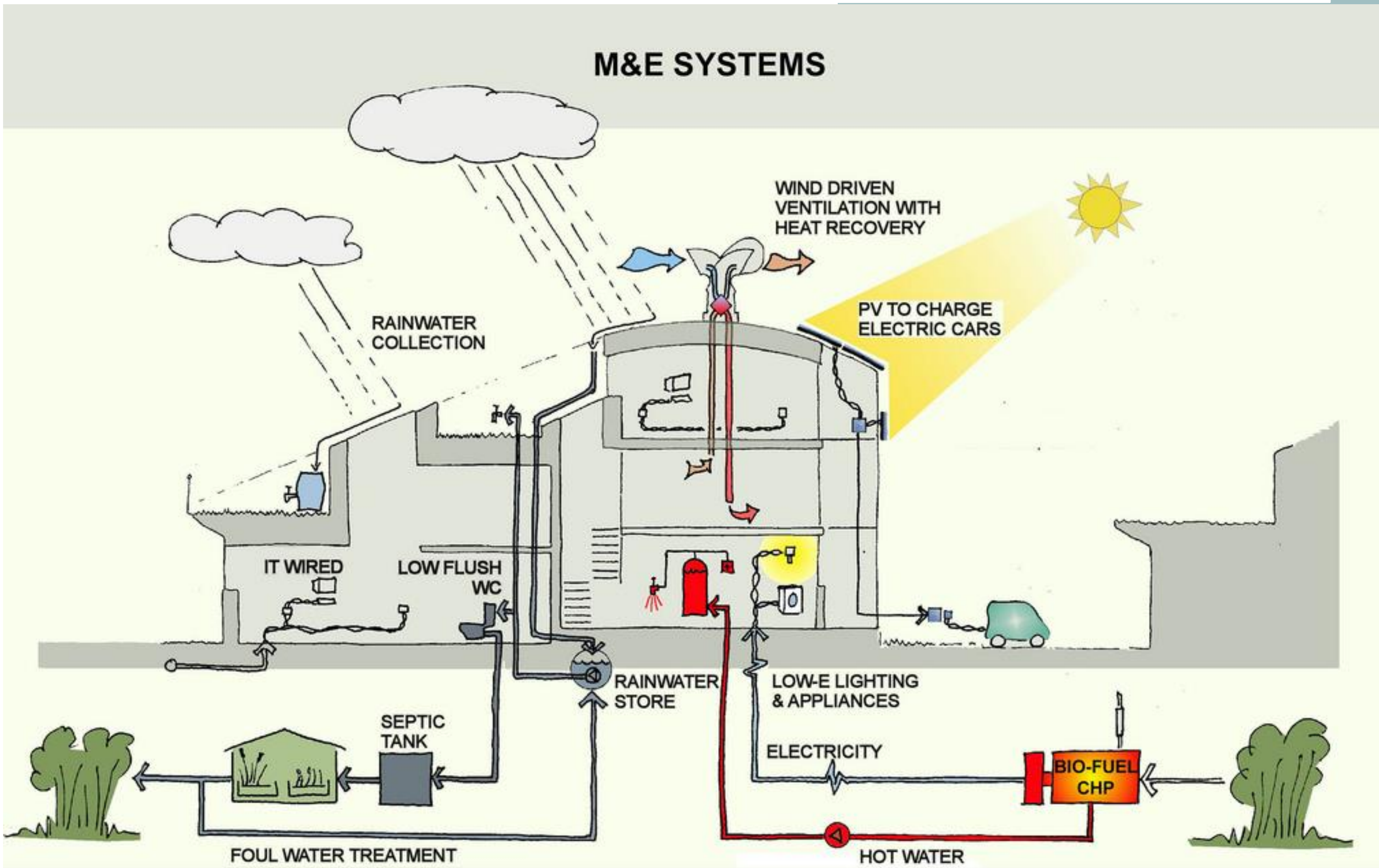
Bio-digester plant under construction

Construction of a Bio-digester plant

12. RAIN WATER HARVESTING

Rainwater should be harvested from building roofs

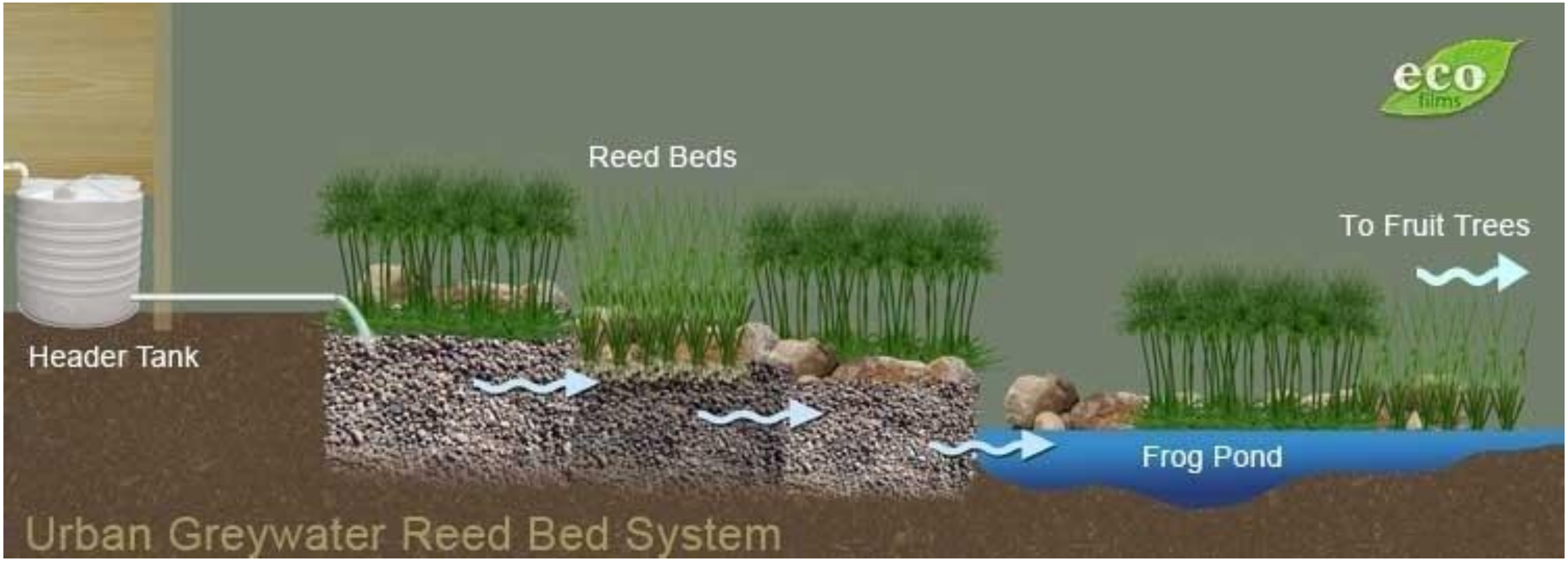
Water tanks next to a building



BEDZED Development , London - Architect: Bill Dunster

13. SANITATION

Use environmentally friendly toilets and sewerage system e.g. bio-digesters, reed bed sewage system , oxidation ponds etc. Toilet waste from the project can be used to produce biogas for cooking and manure.



Reed bed sewage system

14. SOLID WASTE MANAGEMENT

The solid waste generated within a project should be sorted out and the biodegradable waste used to produce biogas and the non-biodegradable waste recycled

Bins for sorting waste

Bins for sorting waste

15. LANDSCAPING

Any proposed development should be landscaped with well-chosen native trees and shrubs etc.

7.0
KEY PLAYERS TO ACHIEVE SUSTAINABLE BUILDINGS

1. OUR GOVERNMENT: BOTH CENTRAL AND COUNTY GOVERNMENTS

- The Government should take the leading role to facilitate and encourage best environmental practice.

- So much so that practically all new government buildings should be environmentally friendly and should be good case studies for "green" building principles.

- The government could give tax rebates as incentive to developers of green buildings or offer cash incentives to green building developers as is the case in Malaysia as well as enact legislation and put in place policies on green building practice.

- There is an urgent need for the Government to put in place legislation on minimum environmental performance of all new buildings.

2. THE BANKING SECTOR

- The banking sector should join in by offering incentives in the form of lower interest rates to developers of green buildings.

- This will go a long way in creating the right atmosphere to spur sustainable building boom in the region.

3.NON-GOVERNMENTAL ORGANISATIONS

- At the same time, AAK, UN-HABITAT and other like minded organisations should actively take a leading role in educating the people why building green is the only way out of the environmental crisis being witnessed today.

- This is not difficult to achieve if the Government is willing.

4. LEADING ARCHITECTURAL/ENGINEERING FIRMS

- The leading architectural practices in the region should be at the forefront in designing environmentally friendly buildings.

5. LOCAL SCHOOLS OF ARCHITECTURE

- There is need for the architectural programs or curricula in our local Schools of Architecture to put emphasis on Sustainable Architecture.

6. MEDIA HOUSES

- There is no better time to create awareness on Global Warming and Climate Change than NOW and Media houses need to take the centre stage.
- There is need to Create Awareness as to why we must built green.

8.0 CONCLUSIONS

From the findings of this paper, it is quite clear why we must emphasise on green architecture in the teaching of architecture and in Architectural practice. The Government must take its central role in promoting Green or Sustainable Architecture.

To this end, there is also need for frequent Conferences and other Continuous Professional Development (C.P.D) programs focusing on Green or Sustainable Architecture if we are to save planet Earth.

It is true that the architecture of the 21st century must be about sustainable/environmental design i.e. "touching the earth lightly" bearing in mind the global phenomenon of Climate Change is here and therefore we do not have a choice but to design and built responsibly.

In conclusion, if we are to save the earth, practicing architects and other professionals in the built environment led by our Government must design and built Environmentally friendly buildings.

Thank you