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Status of Green Buildings in RWANDA: Need and Scope

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***Abstract*:- In this era of global warming due to the excessive burn of fossil fuels, Building Industry has also proved to be one of the major contributors to this scourge of warming the planet earth. The only one option now left for the building sector to tackle this hindrance of global harming is by imposing the green building technology whether in existing building or new buildings for achieving sustainable cities and society, as this issue is more important in underdeveloped and developing countries due to the high economic growth and the increase in energy requirement. As the adage goes " better late than never" September 7th 2016, The Rwanda Housing Authority (RHA) signed a Memorandum of Understanding with the Singapore Building and Construction Authority (BCA) to work jointly towards the development of green buildings and cities in Rwanda; this date marked the start of a new revolution in the Rwandan building sector. This paper puts an emphasis on:**

1.The current Rwandan practices of construction (without incorporation of green building technology)
2.Recently adopted green building technology
3.Incorporation of the green building technology.

Finally this paper concludes by briefly proposing suitable sustainable measures matching with the social, economic and environmental aspects of Rwanda.

Keywords: Green building technology, Rwanda, Climate Resilient buildings, Sustainable buildings, Climate change.

1.INTRODUCTION

From the late of the 18th century to the mid of the 19th century; the world more specifically (western countries) has undergone a period commonly referred to "industrial revolution". Along with this industrial revolution; the world's comfort level has increased at an exceedingly rate. These two parallel era (industrial revolution and world's increase in comfort level) have had their negative effects on the environment.

All man-made actions such as pollution, deforestation have resulted in the change of climate that the entire world is enduring on a daily basis. The harm has already been done and felt by the entire world population and to undergo a reversible process can never be achieved; the only way remaining and which concern all aspects is the implementation of sustainable measures in every man-made action.

Energy and other natural resources are being consumed by the construction industry at an alarming level and this is dramatically affecting the society, economy and the environment [1-8].

Starting with the reduction of these greenhouse gases released in the atmosphere, which are the result of nothing but an excessively dependence on fossil fuels burning such as coal, oil and natural gases will be one major step toward a sustainable development.

Due to the construction industry activities, an excessive amount of carbon dioxide with various other greenhouse gases are being released in the atmosphere resulting in the overall global warming and climate change [9-16].

Increasing and promoting the use of renewable energies should be given enough care and attention to all sectors which contribute most to the destruction of the environment.

The dependence of the construction industry on huge amount proportion of energy and natural resources has resulted in the degradation of the environment, high temperature rise and huge emission of greenhouse gases [17-24].

After assessing all the negatives impacts that the building sector activities produce, adoption of green building technology has been accepted as an effective way of achieving long term sustainable goals in the aspects of environment, economy and society [25-32].

Worldwide it has been accepted that around 50 % of energy consumption is related to building sector and the amount of green house gases released in the whole life cycle of a building can reach up to of 42% [33].

BRIEF INSIGHT ON RWANDA

Rwanda also known as "land of a thousands hills" is an Eastern African country expanding over 26 338km^2. It is surrounded by Uganda to the north; Burundi to the south; Tanzania to the east and The Democratic Republic of the Congo to the west. Being located at 1°56' South and 29°52' Est; it has a moderate climate throughout the year mainly due to its high elevation and the temperature ranges between 17°c to 28°c.

The country's climate is characterized mainly by two rainy and dry seasons in the year. From February to june the first rainy season is observed and the period from September to December is of the second rainy season. The long dry season begins in june and goes up to September and the short dry season spans from December to February [34].

The country also has been affected by the global warming where we are observing an unusual fluctuation in the rainy

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season; where number of rainy days have reduced but the frequency of torrential rains has increased. Rwanda has always aimed to maintain its environment free of pollution; for instance it has been a plastic bag free since the year 2008; due to the fact that these polythene bags are non-biodegradable materials which in turn spoil adversely the soil in which they are disposed off and their combustion after their disposal release harmful pollutant into the atmosphere. Following the country vision of being a climate resilient nation and achieving sustainable infrastructures by the year of 2050; Rwandan government has taken proper measures towards a sustainable development by starting government institutions such as Rwanda Housing Authority (RHA), Rwanda Green Building Organization (RWGBO), Rwanda Environment Management Authority (REMA) and many others to ensure the implementation of the sustainable developments measures. Green building technology in Rwanda and like in many other developing countries it is still in the infancy stage nevertheless the Rwandan Green Building Organization (RWGBO) has recently achieved to propose a technically policy document named as" Rwanda Green Building Minimum Compliance System". Rwanda as a member of Global Green Growth Institute (GGGI) is putting an emphasis to the adherence and implementation of a sustainable development to the property developers.

According to the Rwanda's energy policy, it was planned that 563MW of electricity will be reached by the year of 2018 which would be 70% of the whole population demand and this will reduce the fuel wood consumption from 86.3% to 50%. Rwanda's energy consumption per capita is somewhere around 43 KWH where as Rwanda's per capita GDP is nearly 696 USD. The energy resource in Rwanda primarily comes from biomass which holds about of 85% of whole country's consumption and which is mainly used in cooking and other household necessity. Apart of biomass , the country also has petroleum products and hydropower which contribute to 11% and 4% respectively of the country's energy consumption [35].

Together with the joint collaboration of International Monetary Fund (IMF) along with the world bank, Rwanda has achieved significant economic and structural reforms which made the country to maintain an economic growth rate over the last decade. Rwanda's target is to become a middle income country by the year of 2035 and becoming a high income country by 2050. Up to 2017 and a decade before the growth was estimated to be at 7.5 % and annually a 4.7 % growth of per capita growth domestic products was observed [36].

Sustainable development conception has its roots to the energy calamity (especially fossil oil depletion) and the care of the environment pollution during the 1960 and 1970 year. The need to this sustainable development approach for Rwanda is that; it creates a balance between the environment, social and economic aspects for the country which is commonly referred to triple bottom line. This means while considering the environment and economic aspect of a nation we have to meet also its traditional custom in order to keep its core traditional values.

The next following sections of this paper elaborate the overall evolution of green buildings and the current status of green building technology in Rwanda from the usual way of construction practice to the recently adopted sustainable building technology along with its incorporation.

2. EVOLUTION OF GREEN BUILDING

In southwestern of north America the Anasazi (Native Americans) community, had their own way of design in a such manner that during winter their homes could gain some solar heat. Some sustainability measures such as use of renewable and local materials, passive solar design seem to have started thousand years back [37].

After reviewing many articles and research papers related to green building and sustainable measures, it is not easy to exactly quote when the concept of sustainability entered into the building construction sector's main issues. It apparently seems like there were some studies that were conducted for a span of around two decades starting from 1970s to 1990s about this concept of sustainability. This period was characterized by a lot of lack in understanding this approach of sustainability which was reflected in many public events and debate. In the late of 1990s approximately around 1998 the term eco-building came out in the building sector, and it was followed by Low-energy buildings and passive houses in the year of 2003 and 2007 respectively. Even though there is no scientific proof of explaining why the term passive house was widely accepted as a way of referring to sustainability, but it gained more credits than the previous terms used before for referring the same sustainability concept. Not a long ago that we have started encountering with term Zero-energy buildings or Net-zero buildings that started to spike around the year of 2014, which is simply again a new way of referring to sustainable buildings in which the energy consumed on a yearly basis is equal to the sum of the amount of its renewable energies produced in the same year under consideration [38].

In brazil (Rio de Janeiro) in the year of 1992 at the United Nations Conference on Environment and Development for the first term the notion of green building was officially suggested, aiming for buildings to satisfy the occupants needs such as comfort during all indoor activities and turning building into energy efficient for reducing their negative impacts on the environment [33].

Back again in 1992 the sustainability community of the US started having an idea of turning the white house into a green building for the purpose of raising the public awareness of green building in the US community. Turning the white house into a green building was mainly concerned with the improvement in efficiency use of energy and the performance of its environment by finding out ways of reducing waste, minimizing energy usage, and adopting the use of renewable resources together with enhancing the indoor air quality and comfortability of the white house. In the analysis done in march 1996 to evaluate the outcome of greening the white house has shown that over than 150 000 US dollars annually in energy and water bills, landscaping expenses, and other miscellaneous expenditure related with solid waste were saved. Following 1996 a total amount of 300 000 US dollars were saved annually and over Bill Clinton's presidency a total of 845 metric tons of carbon

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emissions were eliminated yearly. The approach used for greening the white house was focusing on the following: a. Building envelope: reducing energy loss in roof, windows, and walls. b. Lighting: Incorporation of energy-saving light bulbs and enhancing natural light usage. c. Plug loads: Energy-efficient office equipments were installed. Coolers and refrigerators were substituted with much more energy-efficient models. d. Waste: A recycling scheme program was introduced. e. Vehicles: Vehicles using cleaner burning fuels were used [39].

Having seen all the current tragic scenario due to climate change and in which the building sector contributes a lot, the building construction sector is more dedicated than it has ever been before for improving the built up environment and implementing sustainable measures in all phases of construction [33].

For achieving a sustainable built-up environment, green buildings have been accepted as real opportunities and solutions to the negatives footprint left by the construction sector [40-47].

With the help of advanced technologies and scientific management, the chinese ministry of construction in 2007 officially suggested a notion named as green construction, for undertaking construction activities that utilize resources efficiently and minimize the building's impact on the environment together with maintaining the quality and construction safety [33].

The impacts on the environment caused by the building sector can have both direct and indirect effects on the natural configuration of the environment. During any undertaken construction project, buildings are undeniably huge consumers of various different resources such as: raw materials, water and energy and also generate a lot of waste during their construction [48-52].

Even though the more developed countries have experienced faster urbanization and huge infrastructure construction; yet they still excel in aspects of sustainability performance more than the developing countries. This is highly related to the advanced technology level encountered in these developed countries. That being said it is important to evoke the role of government to sensibilise the benefits of sustainable measures so that its implementation can be easily done by any building practitioner [33].

The government part in making policies towards a sustainable development cannot be neglected as there is always a resistance in changing old habits of doing things. Strategies such as offering incentives to organization or individuals who understand the urge of implementing sustainable measures in their construction activities will boost the awareness and compliance to the policies of achieving a sustainable development in all aspects [38].

After realizing all these negative significant impacts that buildings leave on the environment, various green buildings standard and rating systems have been created for mitigating the negative impacts of building on the environment by integrating sustainable design approach. All of these sustainable standards guidelines are made to ensure an efficient way of resources utilization and to evaluate buildings based on how friendly they are with respect to the environment.

Table1. Commonly used major green building rating systems [53]

Sr.no	Green building rating system	Country in which it is being used	Major parameters
1	LEED	USA, Canada, Argentina, Brazil, Chile, Peru, Poland, Spain, Sweden, Turkey, Chinese Taipei, India, Jordan, United Arab Emirates	Location and Transport Sustainable Sites Water efficiency Energy and Atmosphere Materials and resources Indoor Environmental Quality Regional Priority Integrative Process Accredited Professional Innovation
2	BREEAM	United Kingdom, Croatia, Germany, Netherlands, Poland, Spain, Sweden, Turkey, United Arab Emirates	Management Health and Wellbeing Energy Transport Water Material Waste Land use and ecology Pollution Innovation
3	BEAM Plus	Hong Kong	Site aspects Material aspects Energy use Water use Indoor Environmental Quality Innovations and additions
4	Green Mark	Singapore	Energy efficiency Water efficiency Environmental protection Indoor Environmental Quality Other green features
5	CASBEE	JAPAN	Indoor environment Quality of services Outdoor environment

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			Energy Resources and materials Off-site environment
6	GBI	Malaysia	Energy efficiency Indoor environmental quality Sustainable site planning and management Material and resources Water efficiency Innovation
7	IGBC	INDIA	Sustainable architecture and design Site selection and planning Water conservation Energy efficiency Building materials and resources Indoor environmental quality Innovation and development
8	GREEN STAR	Australia, New Zealand, South Africa	Management Indoor environmental quality Energy Transport Water Material Land use and ecology Emissions Innovation

The ultimate goal of green building or sustainable building is to reduce the reliance on non-renewable resources, increase the efficiency utilization of these resources once in use and to promote the usage of renewable resources together with reuse and recycling. Generally the following aspects are given attention when designing a green building:

- Planning of the site
- Proper design of building envelope
- HVAC (Heating ventilation and air conditioning)
- Incorporation of renewable energy sources to produce energy
- Waste and water management
- Proper identification of environmental friendly materials
- Maintenance of a good indoor environmental quality

Advantages or benefits of green buildings:

- Compared to a conventional building, green building consume 40 % to 60 % of electricity less (This is the result of taking into consideration the passive architecture)
- Green building provide direct energy generation by the help of renewable energy such as solar PV panels (which can generate electricity) and solar thermal system (which can supply hot water)
- Green buildings save water to an extent of 40% to 80% when compared to normal building
- During the course their construction the health, safety and sanitation of the laborers is ensured
- Due to the technology of waste management, green buildings generate few waste than conventional building
- During their construction green buildings generate less pollution due to sustainable measures of impacting minute negatives traces on the environment
- Substances which contain ozone depleting potential are not used in green building
- Market demand of green building is increasing worldwide

3. CURRENT RWANDAN PRACTICES OF CONSTRUCTION

3.1 RWANDAN HOUSING CATEGORY

Considering the construction, the configuration manner and also taking into account the economic growth, Rwanda has two housing category:

i. Informal Type of house
ii. Formal Type of house

3.1.1 INFORMAL TYPE OF HOUSE

This type of housing category is made of traditional materials and is mainly dominated by lack of durability and unprofessional quality. This type of house is commonly seen in localities surrounding the boundaries of the capital (KIGALI) and much dominating in rural areas.

Not only this informal type of house do not adhere to the master plan but they are also the main incentive which drive people to keep resisting to adapt the formal type of house and this affect severely the overall accessibility to the basic daily needs such as electricity and water as this informal type of house do not give an easy reach.

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Figure 1.Typical informal houses in Rwanda [54]

3.1.2 FORMAL TYPE OF HOUSE

This house category adheres to all building guidelines provided by the Rwandan building sector and conform to the master plan guidance of that particular area and follows all relevant building codes. This type of house is commonly encountered in urban areas and in some peri-urban localities. Apart from meeting all the standards requirements professional qualities, this type of house is durable and give much more comfort to the occupants.

Figure 2.Typical formal house in Rwanda [55]

3.2 CONSTRUCTION MATERIALS

While most research studies claim that local construction materials should be prioritized but in fact the choice of construction material of any project is a challenging task driven by many factors to be considered before the selection. Some of these factors include :

i. Type of project (important or small projects)
ii. Financial status of the property developer
iii. Quality conformity of the locally available materials in regard to the project to be undertaken
iv. Transportation cost
v. Heavy import charges (in case the material has to be imported)

In view of Rwandan construction materials, the choice of the material will be the result of whether the type of house to be built is informal or formal type of house.

3.2.1 INFORMAL HOUSE BUILDING MATERIALS

Apart from being non-modern materials and lacking professional standards qualities, these materials are easily affordable to most householders who are facing financial obstacles to afford modern materials of construction. The various informal house building materials mostly encountered are: i.Mud brick, ii. Mud plaster, iii. Volcanic stones, iv. Cement screed flooring, v. Clay roofing tiles, vi.Timber and vii. Rammed earth walls.

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Figure 3.Typical informal house wall made of mud brick [55]

3.2.2 FORMAL HOUSE BUILDING MATERIALS

These formal house construction materials met all the modern professional requirements standard and they are also suitable for multiple stories projects. The major disincentive of these materials is that most property owners cannot afford them due to their higher price and most of these materials are imported which also adds some importing charges on their cost. The differents formal house building materials currently in use are: .Reinforced cement concrete, ii. Vitrified tiles, iii. Plain cement concrete brick, iv.Marble, v. Hollow concrete blocks, vi. Ceramics tiles, vii. Fired bricks, viii.Granite tile, ix. Steel and x. Aluminium doors and windows.

Figure 4.Typical formal house wall made of fired brick [55]

4. ADOPTED GREEN BUILDING TECHNOLOGY

Following September 7th 2016, where the Rwanda Housing Authority signed a memorandum of understanding with the Singapore Building and Construction Authority to promote the development of Green buildings and cities in Rwanda. Rwandan government institutions having in charge to promote the sustainable development together with the collaboration of Singapore Building and construction authority have succeeded to propose a mandatory standard for sustainable building which all property developers must adhere to and comply. The policy document proposed is named as ”Rwanda Green Building Minimum Compliance System”. It is a scientifically and technically framed document by professionals expertise in the domain of sustainable development. The framed policy document has five major crucial domains to focus on with more than 30 plus indicators (or sub-domains) and it also ensures the design together with on-site verification to ensure the full compliance. The five major crucial domains are:

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1. Energy Efficiency
2. Water Efficiency
3. Environmental Protection
4. Indoor Environmental Quality
5. Other Green Features

This framed policy document is applicable to : i. Commercial Buildings, ii. Public Administrative and Institutional Buildings, iii. Social, Cultural and Assembly Buildings and iv. Health Facilities v. Educational Buildings.

4.1 ENERGY EFFICIENCY

Rwandan energy resources are primary derived from biomass resources. Among all the biomass products, wood is the mostly used by many in heating and much more needed in cooking.

Rwanda has also adopted sustainable measures of promoting renewable sources of energy. Renewable energy resources available in Rwanda are : i. Solar energy ii. Wind power iii. Geothermal energy iv. Hydropower.

The current trend and the only one feasible approach nowadays is for opting only for the renewable energy as this type of energy has proved to stand as the only way to achieve a sustainable development. The use of non-renewable energy, apart of releasing harmful tonnes of carbone dioxide and other toxic greenhouse gases in the atmosphere, at the same time we are depleting these natural resources of energy which take millions of years to be reformed again.

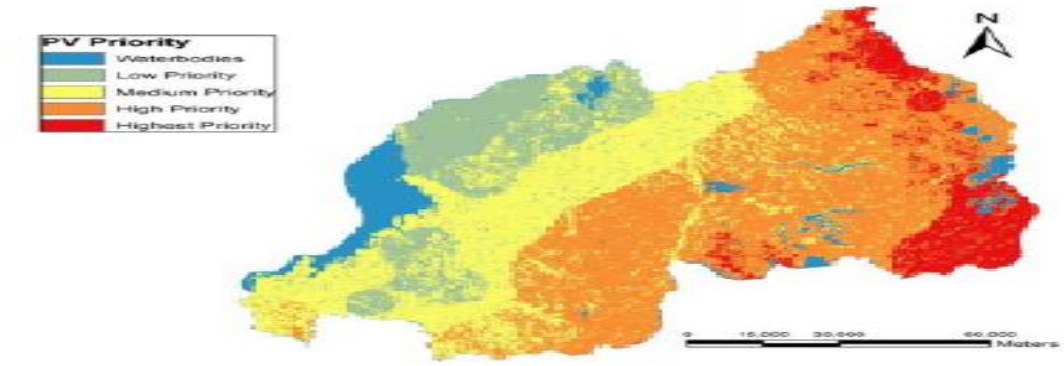

Figure 5. Rwanda Solar map Source [56]

Table 2. Energy sources and estimated potentials in Rwanda [35]

Resources	Potentials	Resources	Potentials
Biodegradable wastes	1MW	Solar energy	(4.3-5.2)×10^{-3}MW/m^2×day
Peat	700 MW	Wind	-
Wood	-	Geothermal	170-320 MW
Methane gas	750 MW	Hydropower	313-400 MW
Biogas	-	Biodiesel	-

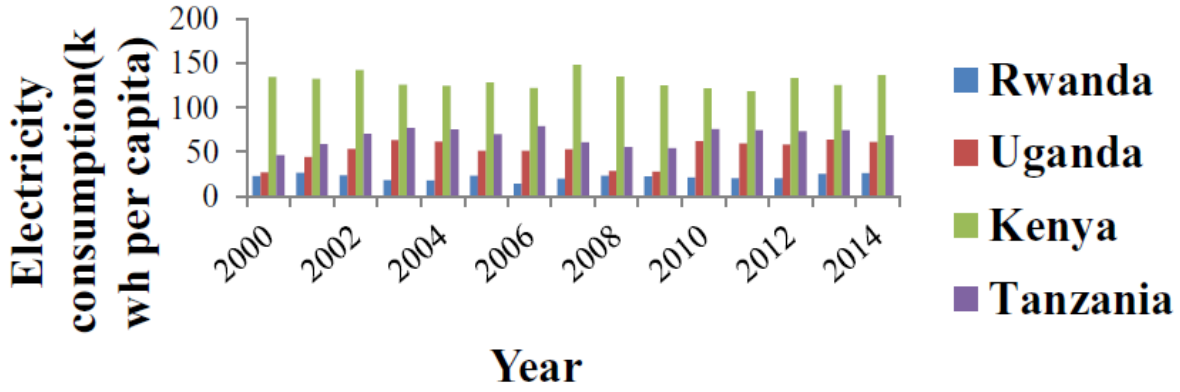

Figure 6 : Per capita electricity consumption of four east African countries[35]

The sub-domains available within this domain of energy are: i. Building envelope for air-conditioned and non-air conditioned space. ii. Better thermal transmittance (U-value) for roof. iii. Air conditioning system. iv. Natural ventilation. V. Day lighting. Vi. Lighting efficiency. Vii. Ventilation in car parks. Viii. Ventilation in common areas. ix. Lifts and escalators. x. Energy efficient practices. xi. Renewable energy. xii. Solar hot water system. xiii. Energy metering

4.2 WATER EFFICIENCY

Especially in the water and sanitation sector, figures which represent people with access to clean drinking water have increased from 68 % in the year of 2006 up to 74.1% in the year of 2012. Statics also show that Rwandan people who

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have access to hygienic sanitation have increased from 38 % in the year of 2006 to 74.5 % in the year of 2012 [57].
Water efficiency is often misunderstood as a restriction of water usage but in fact when the amount of water supplied for any required purpose is equal to the amount demanded for the same purpose then there is no wastage of water and in this context we can speak of water efficiency.
The ultimate goal under this domain is to replace the conventional means by using high efficiency water technology such as: The use of rain water, recycling on-site water so that we can limit the consumption of potable water to the lowest possible level.
The sub-domains or indicators are:

- Efficient plumbing fixtures
- Rain water harvesting
- Waste water treatment
- Treated waste water reuse
- Water metering.

4.3 ENVIRONMENTAL PROTECTION
Rwanda being one of the few nation worldwide which has succeeded to ban the use of plastic bags since 2008; it is also ensuring that human activities impact minute effects on the environment for achieving a sustainable development and safeguarding its environment. The indicators associated with this domain are :

- Sustainable construction materials
- Greenery provision
- Environmental management practices
- Segregation of waste
- Construction waste management
- Heat island reduction
- Soil erosion and sedimentation control.

4.4 INDOOR ENVIRONMENTAL QUALITY
Most of people are seldom aware of the term “Sick Building Syndrome”. The fact is this sick building syndrome is a feeling that most people do get while spending time in building and can be worsened with the increase in time spent in building or completely disappear once out of the building. In this domain making the occupants feeling comfortable is the main focus and priority. The sub-domains or indicators attached within are:

- Minimum mechanically ventilated spaces
- Thermal comfort
- Noise level
- Low volatile organic compounds (voc) paints and adhesives.

4.5 OTHER GREEN FEATURES
Continuous improvement is a virtue by which any organization whether private or public rely on to assess its quality standards, if it is as expected or planned. Same goes with other green features also where the objective is always to come up with much more diversified innovative ideas and going the extra mile in terms of sustainability improvement. Within this domain the sub-domain present are:

- Innovation
- Optimum use of developable land
- Universally accessible building.

5. INCORPORATION OF GREEN BUILDING IN RWANDA

As this notion of green building technology still in its infancy stage the government is sensibilizing the citizens to get their homes assessed for conformity to a sustainable standard. Up to date the Nobelia Office Tower in Kigali is the officially awarded green building rating certificate by The Green Building Council of Rwanda and the newly on-going construction of Bugesera Airport will be the first green certified airport in Africa.

6.CONCLUSION

Given the climatic condition of Rwanda from which we can clearly observe that there is no need of active ventilation in residential buildings apart of business buildings; achieving a sustainable development can be afforded at the lowest cost possible. Driven by the aim of reaching a good balance between durability and less environmental negative impact; The Rwandan building sector can succeed to promote a sustainable development with much more financial and environmental benefits. Following are some brief points of consideration in regard with the social, economic and environmental aspects of Rwanda.

1.SOCIAL
Comfortability and boosting human productivity must be the two importants key factors of the Rwandan green building designer to mark the difference with the conventional ways.

2. ECONOMIC
Making use of locally available materials and proper selection of imported ones will give financial advantages in promoting sustainable development.

3. ENVIRONMENT
Given the hilly topography of Rwanda, sustainable sites should be given more concern as one of the domain of green building rating system, due to the fact that the hilly nature requires massive excavation of soil during construction and slope stabilization which lead to top soil depletion and erosion.

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