

# Contributions of Green Buildings to Sustainable Development of Kigali, Rwanda

NIYONZIMA Emmanuel  
Dr. MUPENZI Christophe

**Abstract**—This study aims at evaluating how green buildings contribute to Rwanda's sustainable development, in the city of Kigali. By 2050, 68% of the population of the world will be living in cities. The transition from rural to urban results in a 78% rise in energy consumption and 60% increase greenhouse gas emissions and this leads to an alarming rise in environmental awareness and concern. Green construction for a sustainable environment is a solution particularly for Rwanda which has more than 50% of the population being under twenty-five years old. The research has three main objectives including: Firstly, to identify the components of green buildings in City of Kigali; secondly, to examine the strategies for enhancing the green buildings practices adoption in Rwanda and thirdly, to determine the contributions of green buildings toward the achievement of sustainable development in Rwanda from 2016 to 2021. Different research methods were used interviews, observations, and questionnaire. Through observations, green buildings were identified in the city of Kigali and these are highly contributing to the protection of environment, promotion of social welfare and to the economic growth of Rwandans, particularly citizens of Kigali City through provision of job, better indoor air quality for occupants, wastes management and use of ecological construction materials. Components of green buildings were identified through questionnaire and interviews. The respondents highlighted improving practitioners' abilities, sustainable urban planning, supporting renewable energy sources, conducting energy audits on buildings falling under categories four and five, modifying building finishing methods, controlling stormwater, and certifying green buildings as strategies to promote the adoption of green buildings in City of Kigali. 90% of respondents revealed that green buildings contribute to sustainable communities and cities particularly in the city of Kigali. Additionally, green buildings support worldwide cooperation, responsible consumption and production, effective energy use, excellent health and wellbeing, and innovative and sustainable infrastructure. In the city of Kigali, around 90% of respondents said that green building practices included the use of renewable energy. In this study, respondents added that efficient building envelopes, lighting, ventilation, plumbing fixtures, building waste management, and organic gardening also as elements of green buildings in the city of Kigali. according to the findings, the green building policy should be enforced for multistoreyed buildings not easy for small houses. The research propose some recommendations to Government of Rwanda, investors, building developers and practitioners, and researchers.

**Index Terms**— Green buildings, green building Concept, Sustainable Development, Conventional building, Environmental Sustainability, Sustainable Economic Growth, Urbanization.

## 1 GENERAL INTRODUCTION

The concept of green building technology has very long tradition in the history since 1800s. Since then, the building contributed to the pollution of the environment and this emerged a quick adoption of green building for efficient energy use, ecological construction materials, cost effective buildings and promotion of wellbeing of buildings' occupants. Building's construction activities consume 32% of world energy consumption and are and 19% of greenhouse gas emissions (UN, 2022). Green buildings contribute significantly to sustainable development by enhancing human well-being, promoting renewable energy for inexpensive and clean energy, and boosting the economies of countries by giving decent employment and business possibilities (UN, 2015). Rwanda Housing Authority struck an agreement with the Singapore Building and Construction Authority in September 2016 to increase the adoption of green buildings and green urbanization in Rwanda. The density of the population of Rwanda will continue to increase regardless of the measures currently taken to mitigate its evolution. The current density of 501 inhabitants per square kilometer 2022 and is already one of the highest in Africa and will rise to about 894 at the end the projection in 2052 (Fifth Rwanda Population and Housing Census). This high population growth increases the demand of buildings particularly in City of Kigali; with this situation, natural resources should be used efficiently and wastes should be well dis-

posed. This research of contributions of green buildings to sustainable development in city of Kigali aims at identifying the components of green buildings, strategies of adoption of green buildings and contributions of green buildings to sustainable development of Kigali. More details are in the results and discussion. Government of Rwanda is recommended to enforce the implementation and awareness of green building technologies.

### **Authors:**

*NIYONZIMA Emmanuel holds advanced diploma in civil engineering, and Bachelors of science in environmental management and conservation; persuing masters of environment and development. Phone number: +250785064143. E-mail: nzimaemmy67@gmail.com*

Dr. MUPENZI Christophe, holds PhD in environmental sciences. Phone number: +250788666156. E-mail: mupenzi@gmail.com

This research paper aims to find answers to the following questions:

- What are the components of green buildings in Rwanda?
- How to enhance green buildings strategies adoption in Rwanda?
- What are the contributions of green buildings towards the achievement of sustainable development in Rwanda from 2016 to 2021?

A questionnaire was designed to 160 respondents from three different districts in the City of Kigali. Useful for letting people know that green building construction boosts the economies of nations by creating decent employment and business prospects while also enhancing human wellness and promoting renewable energy for inexpensive and clean energy. More significantly, anyone attempting to lower their use of natural resources gain from the study. Therefore, by minimizing water usage and energy sources that harm the environment, this research added to the body of knowledge already available on the benefits of green buildings to the climate and general ecosystem.

## 2 CONCEPTS OF GREEN BUILDING

Cities have a big influence on climate change even though they only make up less than 1% of the surface of the planet. Cities will be home to 60% of the world's population by 2060, up from 50% currently. Up to 75% of greenhouse gas emissions and 75% of the world's energy are produced by cities and metropolitan areas, respectively. Cities utilize 60 percent of the water in the globe, either directly or indirectly. Cities or components of city life thus directly account for most of the the world's energy use (Ji and Plainiotis, 2006). Buildings that are built with greening techniques to reduce or eliminate negative effects on the environment and the health of inhabitants, and to do this properly, reduce waste and pollution, utilize renewable energy sources, and use other resources like water. Green building technology is the result of a design that puts more emphasis on boosting resource usage, energy, water, and material efficiency while minimizing the effects of buildings on human health and the environment over the duration of the building's lifespan (Ji and Plainiotis, 2006)

certified green buildings consume 40-50% less energy and 20-30% less water (IGBC,2019). Green building technology promotes utility cost savings owing to efficient use of energy and water, cheaper construction costs, and increased property value for building developers; it also provides jobs and supports the nation's economic progress. Owners of green buildings have reported to have an increased asset value of 7% over owners of traditional buildings. Green buildings also increase profits and asset value, boost employee productivity and satisfaction, and optimize life cycle economic performance, saving owners money on energy, maintenance, and operating costs (IGBC,2019). By enhancing the health and comfort of building inhabitants, enhancing their interior air quality, encouraging aesthetic characteristics, supporting psychological wellness and stress reduction, and displaying cognitive function, green buildings help to enhance worker productivity and comfort at work. While this is going on, green buildings serve several purposes and are typically categorized as multidimensional designs and techniques that are good for both the environment and human health. To aid in research and design, poli-

cymakers and the building sector have classified green building ideas. These include resource conservation, water conservation, indoor air quality, livable communities, and energy efficiency (IGBC,2019).

## 3 METHODOLOGY

A research design is a strategy that describes how data were acquired from an assessment, including selecting data collection techniques, developing the instrument, administering the instrument, and organizing the results (Bryman, 1998). Specific techniques were used to identify, select, process, and analyze information during this research. Different research instruments were employed including observations, questionnaires, and interviews. Data analyses were done with the help of MS Office software (Word, Excel, PowerPoint) and GIS to produce land cover of City of Kigali. Both primary and secondary data were used. A sample is a discrete set of instances chosen from the larger population or group under inquiry. Consequently, sample size is the number of individuals or objects included in the chosen sample (Manheim and Rich, 1995). Since green building concept is new in Rwanda a purposive sampling was employed to carry out this research. In research when population is less than one million, we correspond this to sample 96 and it give an error of 10% (Grinnell & William, 199).

$$Nc=(N*n)/(N+n)$$

**N:** Size of population (Green building: Already Constructed or in the pipeline),

**n:** Sample of 96, since population is then than one million,

**Nc:** Sample size

$$Nc= (11*96)/ (11+96)$$

$$Nc=(11*96)/ (11+96) = 1,056/107=9.86 \text{ buildings.}$$

Only 10 buildings were to be utilized as a sample because the green building idea is new in Kigali City, and 160 persons were specifically employed to enhance the research. Purposively 160 respondents to the research were selected, who were spread over Kigali's three districts, consisted of 35 building tenants, 10 building owners, 30 civil engineers, 10 architects, 15 electrical engineers, 30 environmentalists, 20 technicians, and 10 government officials.

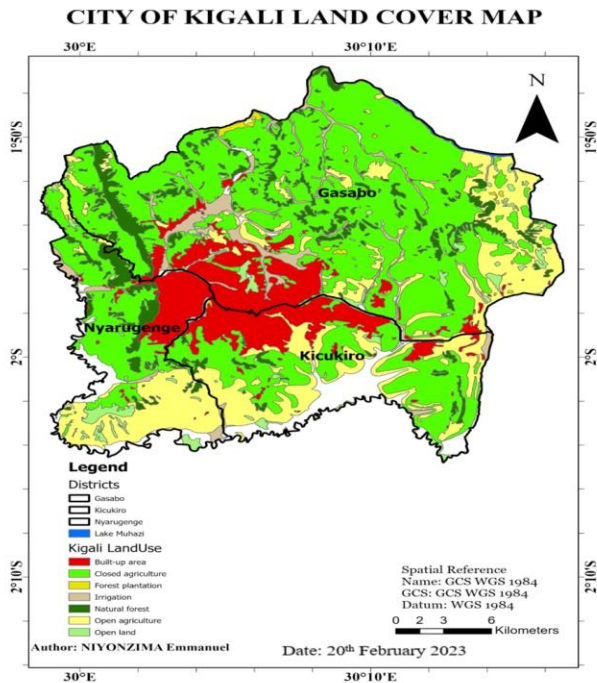


Figure 2.2: Landcover of City of Kigali.

## 4 RESULTS AND DISCUSSION

This chapter focuses on the analysis of data collected through interviews, questionnaire surveys, and observation to meet the research objectives. These data were represented in descriptive statistical table and percentages. Based on the three research objectives and research questions, information was gathered from 160 respondents from various categories such as building developers, civil engineers, architects, electrical engineers, environmentalists, local authorities, government authorities, technicians, and building occupants spread out across the three districts of Kigali.

### 4.1 Gender information of respondents

Table 4.1: Genders of respondents

S/N	Gender	Total Number	Percentage (%)
1	Male	115	72
2	Female	45	28
<b>Total</b>		<b>160</b>	<b>100</b>

Primary Data (2023).

The above table reveals that 160 people participated in the research and among them 72% are male and 28% are female.

### 4.2 Level of education of respondents

Table 4.2: Level of education of respondents to interviews

S/N	Level of education	Number	Percentage (%)
1	Primary School	1	0.6
2	Ordinary level	5	3
3	High School	20	12.6
4	Diploma	54	33.8
5	Bachelor or higher	80	50
<b>Total</b>		<b>160</b>	<b>100</b>

Primary Data (2023).

According to the table 4.2, among those who participated in the interviews, 6% were building owners, 19% were civil engineers, 6% were architects, 9% were electrical engineers, 19% were environmentalists, 13% were technicians, 6% were members of government agencies, and 22% were building occupants.

### 4.3 Profession of respondents

Table 4.3: Profession of respondents to interviews

S/N	Profession	Number	Percentage (%)
1	Building owners	10	6
2	Civil engineers	30	19
3	Architects	10	6
4	Electrical engineers	15	9
5	Environmentalists	30	19
6	Technicians	20	13
7	Government authority	10	6
8	Building occupants	35	22
<b>Total</b>		<b>160</b>	<b>100</b>

Primary Data (2023).

According to the table above, among those who participated in the interviews, 6% were building owners, 19% were civil engineers, 6% were architects, 9% were electrical engineers, 19% were environmentalists, 13% were technicians, 6% were members of government agencies, and 22% were building occupants.

### 4.4 District of resident of respondents

Table 4.4: District of resident of respondents across the City of Kigali

S/N	District	Total Number	Percentage (%)
1	Gasabo	55	34
2	Kicukiro	45	28
3	Nyarugenge	60	38
<b>Total</b>		<b>160</b>	<b>100</b>

Primary Data (2023).

The aforementioned table shows the distribution of interview respondents among the districts of the city of Kigali, with 34%, 28%, and 38% of respondents in Gasabo, Kicukiro, and Nyarugenge, respectively.

### 4.5 Green buildings observed during the research

In Rwanda green building policy address buildings under category 4 & 5 as per Rwanda Ministerial Order Determining Urban Planning and Building Regulations, and these are commercial buildings Public administrative and institutional buildings, assembly and health facilities buildings, and educational buildings constructed from 2016 to 2021, in City of Kigali, below are some buildings observed through Districts of City of Kigali. Through observation and interview and questionnaire the researcher got various information

Table.4.5: Some of observed green buildings in Kigali

S/N	NAME OF THE BUILDING	STATUS
1	I&M Building	Completed
2	Norsken Rwanda	In progress
3	KIST architecture building	Completed
4	Saint Famille Hotel	Completed
5	Kigali Green complex Building	To be constructed
6	Girinzu Urban Village	In progress
7	Green city in Kinyinya	In progress
8	Peace Building Apartment	To be constructed
9	Inzovu Mall	In progress
10	Nobelvia Tower	To be constructed

Primary Data (2023).

#### 4.6 Components of green buildings in Rwanda

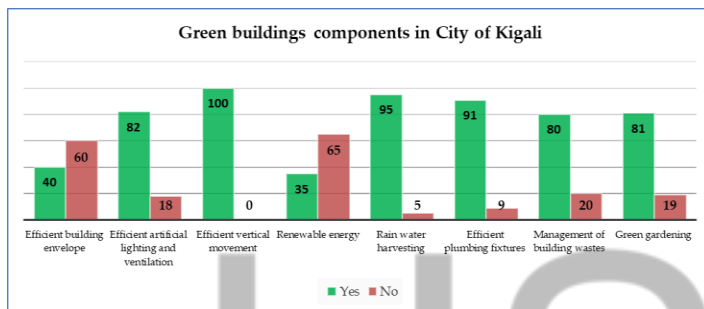


Figure 4.1: Components of green buildings in city of Kigali Primary Data (2023).

The first research objective was to identify the components of green buildings in Kigali. Figure 4.1 depicts the opinions of 160 respondents on the components of green building in the City of Kigali, revealing that 40% of respondents reported building envelope and design that encourage the efficient use of energy as components of green building in the City of Kigali, while 60% did not. 82% of respondents agreed that effective artificial lighting and ventilation are components of green architecture, while 18% disagreed. In City of Kigali, 100% of respondents agreed that efficient vertical mobility is an important component of green architecture. 35% of respondents agreed that renewable energy is a component of green building, however the remaining 65% disagreed. Rainwater collecting was reported as a component of green architecture by 95% of respondents, whereas 5% refuted this argument in City of Kigali. In City of Kigali, 91% of respondents agreed that efficient plumbing fittings are a component of green building, while 9% disagreed. In Kigali, 80% of respondents agreed that building construction wastes management is an important component of green building, while 20% disagreed. All homes garbage are collected in Kigali, and construction wastes are also collected and properly deposited, although recycling is not adequately reinforced due to a shortage of waste treatment businesses. Recycling of building construction wastes is also progressing continually. Furthermore, 81% of respondents verified gardening as components of green building in Kigali, while 19% do not view gardening as a component of green building in Rwanda due to the lack of vertical planting (Gardening) in buildings.

#### 4.7 Strategies for enhancing the adoption of green building in Rwanda

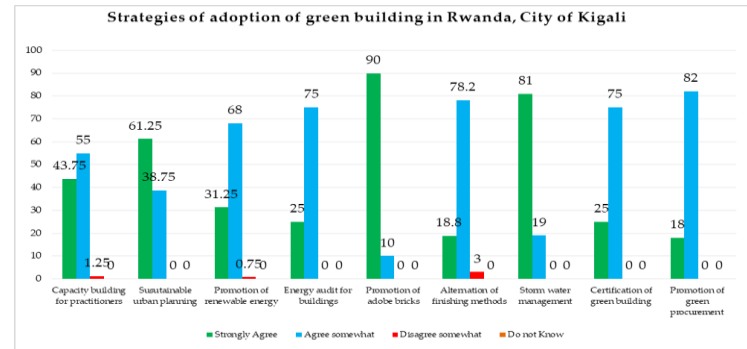


Figure 4.2: Strategies of adoption of green building in Kigali Primary Data (2023).

The second research objective was to identify strategies to enhance green buildings adoption in Rwanda, City of Kigali. According to figure 4.2, 43.75% of respondents strongly agree with the idea of increasing practitioners' capacity as a means of implementing green construction in the City of Kigali, while 55% of respondents agree somewhat and 1.25% disagree slightly. A strategy for the implementation of green construction in Rwanda is sustainable urban planning, which is agreed upon by 61.25% of respondents strongly and 38.75% of respondents slightly agree. Regarding the promotion of renewable energy as a strategy for green building adoption in City of Kigali, 31.25% of respondents strongly agree, 68% agree slightly, and 0.75% strongly disagree. Energy audit is one of the measures for adopting green building in the City of Kigali, although only 25% of respondents strongly agreed with this claim, and 75% disagreed somewhat. About 90% of respondents strongly agreed and 10% somewhat agreed that the City of Kigali should promote the use of adobe bricks for green building. 78.2 % of respondents somewhat agreed and 18.8% strongly agreed on alternation of finishing methods as a strategy to promote green building. Stormwater management is a technique for Rwanda to adopt green building, according to around 81% of respondents, and 19% agreed strongly agreed and agreed somewhat respectively. According to the survey results, 25% of respondents strongly agreed and 75% somewhat agreed that Rwandan buildings should be certified as green. The promotion of green procurement as a plan to embrace green building for sustainable development in the City of Kigali was also supported by 18% of respondents strongly and 82% moderately. In summary Rwanda should enhance the use of green construction techniques in City of Kigali, 96% of respondents said.

#### 4. 8 Contributions of green buildings to sustainable development of Rwanda, City of Kigali

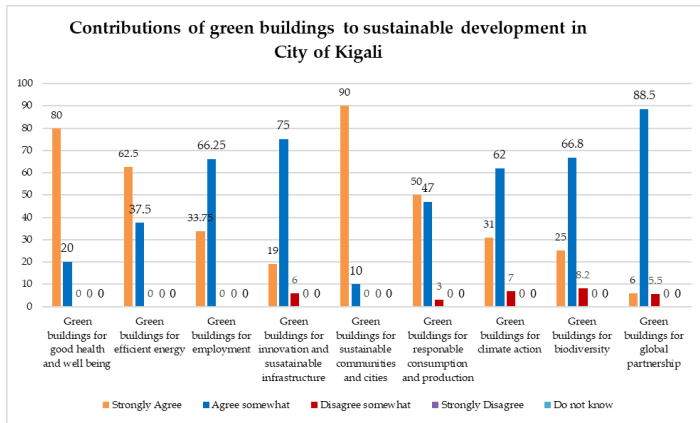


Figure 4.3: Contributions of green buildings to sustainable development in City of Kigali. Primary Data (2023).

The third research objective was to assess the contributions of green buildings to sustainable development in City of Kigali. The figure 4.3 reveals that: Green construction contributes to the city of Kigali's sustainable development, according to 80% of respondents who strongly agreed and 20% who agreed slightly, and this is aligned with sustainable development goal 3(SDG3). According to 62.5% of respondents, energy efficiency (SDG 7) and other factors help the city of Kigali develop sustainably.37.5% of respondents said they somewhat agreed with this assertion. In response to the claim that green buildings increase employment, 33.75 percent and 66.2 percent of respondents agree strongly and moderately, respectively (SDG 8). Green construction contributes to the creation of climate-resilient infrastructures, according to around 19% of respondents who strongly agreed, 75% of respondents who agreed somewhat, and 6% of respondents who strongly disagreed (SDG 9). Green buildings contribute to responsible consumption and production in Kigali, according to 50% of respondents who strongly agreed, 47% who agreed slightly, and 3% who strongly disagreed. Green construction contributes to responsible climate action, according to 31% of respondents who strongly agreed, 62% who agreed somewhat, and 7% who strongly disagreed (SDG13).25% of respondents strongly agreed, 62% of respondents agreed somewhat and 6% strongly disagree that green building promote biodiversity and conserve resources of the city of Kigali (SDG,15). Finally, 6% of respondents strongly disagreed, 88.5% agreed slightly, and 5.5 disagreed somewhat that the Green Building Rating System fosters international connections (SDG 17).

#### 4.9 Challenges of green buildings adoption in city of Kigali

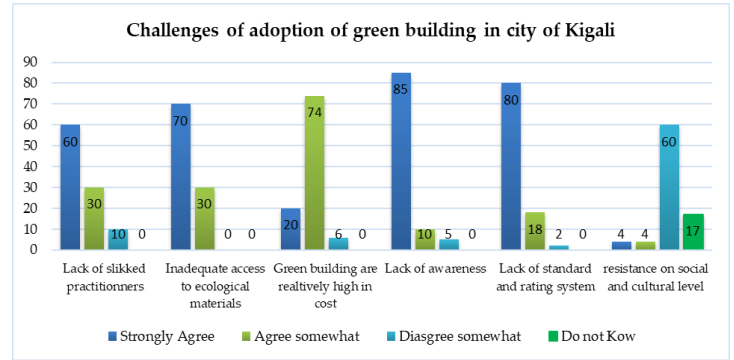


Figure 4.4: Challenges of adoption of green building in city of Kigali. Primary Data (2023).

#### 4.10 Results Discussion

According to the findings, the green buildings have a huge contribution to sustainable development of the city of Kigali. So, the objective was achieved, and the null hypothesis is verified. Even if the green building concept is new but the citizens of the City of Kigali understand well its relevancy to the sustainable development of the city. As far as strategies of green building adoption in Rwanda is concerned, Government established different policies that clearly elaborated the vision of green buildings in Rwanda. Developing countries will significantly increase carbon dioxide emissions, making green building technology a sustainable solution to this issue (Harvey, 2009). This research reveals the encouragement of use of renewable energy and training of green building practitioners among other highlighted strategies should be reinforced. More than 80% reported some challenges of adoption of green building concept in Rwanda including: lack of skilled practitioners, inadequate access to ecological construction materials, high initial cost, lack of awareness, lack of standard rating system and social and cultural resistance. Basing on research findings, the application of green building technologies is only possible at the level high buildings under the category 4 and 5 as defined by Rwandan government; these buildings are for example commercial buildings public administrative and institutional buildings, assembly and health facilities buildings, and educational buildings. During the research, the interviewed government authority revealed that the promotion of green building is crucial in order to meet sustainable development through protection of environment, promotion of wellbeing of society and economic growth of Rwandans. UN Sustainable development agenda highlight the relationship between green buildings to sustainable development; in this research the respondents confirmed this relationship that green buildings contribute to good health and wellbeing (SDG3),water efficiency (SDG6), energy efficiency(SDG7), decent work and economic growth(SDG8),industry, innovation and infrastructure(SDG9), reduce inequality through job opportunities(SDG10),sustainable cities and communities(SDG 11), responsible consumption and production of construction materials(SDG 12), reduction of emissions (SDG 13), protec-

tion of biodiversity(SDG 15), countries working together for practicing green building technologies(SDG17).Promoting the use of renewable energy sources over non-renewable ones, emphasizing water and energy efficiency in building operations, and focusing on environmental quality, minimizing economic costs, enhance use of local construction materials, and maintenance of identity of the culture for current and future generation (Hasanpour Lumer, 2014); the current research proves this argument of Hasanpour Lumer where majority of respondents reveals that water efficiency and energy efficient are essentials for sustainable development of city of Kigali. But the journey is still long and with master plan there is a hope to achieve energy and water efficiency. The use of energy-efficient lighting, ventilation, and air conditioning may cut energy usage by 64%(Rodes,2011); in this research the respondents failed to align with this argument because the green building concept is still new in Rwanda to have sufficient records. Energy utilization for heating, ventilation, and air conditioning in green buildings is reduced by 35% compared to conventional structures (Scott,2009); the owners and developers of green buildings in the city of Kigali proved this argument during this research and most importantly, Norsken building owners are planning to go further this argumentation.

## 5. CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

According to the findings of the study, Kigali residents understand the importance of green buildings in Rwanda. Although the idea is relatively new, Rwandans will be able to implement green building technology through various efforts thanks to an existing master plan and green building legislation. The respondents ranked the following factors in order of importance for the first research goal of identifying green building elements in the city of Kigali: efficient vertical movement, rainwater harvesting, efficient plumbing fixtures, efficient artificial lighting and ventilation, energy efficiency through the promotion of renewable energy, efficient building envelopes, management of building wastes, and gardening. The people of Kigali strongly favor the use of green building construction methods, both for environmental preservation and for the sake of the city's socioeconomic development.90% of respondents strongly agreed that the promotion of ecological construction material like soil bricks is a good strategy for adopting green buildings in the city of Kigali, along with 43.7% of respondents who strongly agreed and 55% of participants who somewhat agreed, and respondents ranked other strategies from sustainable urban planning, the promotion of renewable energy, stormwater management, energy audits for buildings in categories four and five, and green building certification as strategies. The Kigali master plan outlines how all building types should preserve the environment and foster socioeconomic development, and in general, green buildings significantly contribute to sustainable development compared to conventional structures. In terms of wastes management city of Kigali. In accordance with Rwanda National Strategy One, which calls for electrifying the entire nation by 2024, storm-

water is well handled in the city of Kigali. Therefore, adopting renewable energies like solar energy and clean cooking should be planned to accomplish this energy efficiency. Regarding the third research goal, which was to determine how green buildings contributed to the city of Kigali's sustainable development, 95% of respondents said that green buildings helped create livable neighborhoods and cities free of social unrest and natural disasters. Additionally, 80% of respondents said that green buildings improved people's health and wellbeing. Finally, green buildings significantly increased energy, construction materials and water efficiency and job creation. Other noteworthy ways that green buildings contribute to the city of Kigali's sustainable development include innovation and sustainable infrastructures, responsible consumption and production, climate action, promoting biodiversity, and strengthening international cooperation. The results showed that there is a need for green building practices to be strengthened, green building rules to be enforced, green building technology to be educated, etc. Fortunately, Kigali has a number of green construction projects in the works, including the Nobelia tower, Kigali green building complex, and green city in Kinyinya Sector. Additionally, Rwanda is building Bugesera international airport, the first green international airport in the region of east Africa. The adoption and promotion of green buildings practices in Rwanda City of Kigali are limited on high building under category 4 and 5 as defined by Rwanda Housing authority and not for small residential buildings.

### 5.2 Recommendations

Based on study findings on the contributions of green buildings to Rwanda's sustainable development, specifically in the instance of the City of Kigali, the author would like to provide recommendations to the Rwandan government, construction professionals, investors, and researchers.

#### 5.2.1 Recommendation to the government of Rwanda

In order to improve the green building: Government should continue reinforcing the master plan 2050 implementation in city of Kigali, project developers and practitioners to abide to the master plan of city of Kigali, government should enforce the polices, awareness and training of greenbul ding technologies, government to provide incentives for people involves in the renewable energy services, follow-up on policy enforcement as well as training and education that emphasize sustainability, Rwandan government may hire international specialists while also offering training so that we can develop our own expertise, local green materials should be supported and encouraged by the government.

#### 5.2.2 Recommendations to building developers and practitioners

Based on research findings, the researcher recommends that building developers and practitioners should prioritize the use local ecological construction materials, to raise the demand for green buildings, training on awareness and adoption of environmentally friendly structures and goods must also be atten-

tive, not only to the key players in the construction sector but also to the public and government should promote a better comfort in the design, implementation and operation of the buildings.

### 5.2.3 Recommendations to investors

Basing on research findings, the researcher recommends investors to fund local manufacturers, suppliers, or construction enterprises to be more ecologically friendly, investors should fund the development of standard and guidelines of use of ecological materials and green building innovations, financial organizations like banks may offer more enticing financing to investors in green development, financial institutions should offer green incentive programs and tax breaks for construction businesses and other green development players, manufacturers in the area should get financial assistance and incentive schemes, instead of relying entirely on the government, the private sector should build its own green plan.

### 5.2.4 Recommendations to researchers

This study recommends to researchers to conduct more investigation on Rwandans' perceptions and understanding of green buildings. Researchers should identify in details more relevant components of green buildings in Rwanda not only in City of Kigali but also in other provinces. Researchers are recommended to deepen the strategies for enhancing green building practices adoption in Rwanda.

## Appendices

### Appendix 1: I&M Commercial Bank Headquarters building



I&M Headquarters constructed in City Center, Nyarugenge District: This building uses high quality ecological clay burnt bricks which eliminate the cost of plastering and painting; the building is well ventilated and lighted which promote the wellbeing of occupants. The roof of the I&M Building is comprised of solar panels, which produce power for the building and cut electricity bills from the national grid (Energy efficiency). The sanitary appliance and plumbing fixtures are using intelligent system which promote the water efficiency. Despite

the small size of the property, the home boasts a garden. These elements make this structure eligible to be considered green.

### Appendix 2: Norrsken House Kigali constructed in the city Center, Nyarugenge



Norrsken House Kigali constructed in the city Center, Nyarugenge District in the plot of late Ecole Belge compound: The Norrsken Kigali House will be EDGE Advanced certified, which means that its buildings will have on-site energy savings of at least 40%. It is a leading example of green construction development. The design emphasizes clay-shaded facades and natural ventilation for temperature management and ventilation, and features a thermal labyrinth, a ground-breaking sustainable cooling system, to lower energy requirements. Additionally, the facility's rooftop solar photovoltaic system contributes to maximizing energy independence. The new environmental building certificate standard incorporates a design tool to support the economic justification for developing green buildings. Developers, building owners, and investors may quickly evaluate the environmental and financial effects of every design choice thanks to EDGE.

### Appendix 3: Green building projects in the pipeline of Peace Building Apartment at Nyarutarama, Gasabo District



This apartment will make the most use of the available space, maximize natural air circulation and ventilation, and assure energy efficiency through the use of solar glass walling. Only water-efficient plumbing fixtures and appliances will be utilized in this apartment, and all rainwater from the roof will be collected and stored in tanks. To ensure that the environment has fresh air, gardening will be done both horizontally and vertically. There will be treatment and reuse of all wastewater. To save electricity and water, all stormwater is handled on-site or gathered and used for non-potable water services such as toilet flushing. Following flushing, the water is sent to the on-site wastewater treatment plant. Treated water seeps into the soil through infiltration trenches beneath on-site gardens. This decreases the probability of damaging flash flooding consequences on downstream vulnerable areas. When these conservation strategies are combined, the campus design delivers a 32% decrease in embodied carbon when compared to the worldwide average for equivalent office buildings.

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