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Assessment of Awareness level of Green Building Concepts in Kigali commercial property development

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university

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The thesis has been submitted for examination with my approval as the university supervisor.

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DEDICATION

I humbly dedicate this research to my loving mother and father for their endless guidance and support, to my wife Valerie and my child Dylan who have been my source of inspiration and gave me strength when I thought of giving up; who continually provided their moral, spiritual, emotional, and financial support.

And lastly, I dedicated this book to the Almighty God, for the guidance, strength, power of mind, protection and skills and for giving me a healthy life.

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LIST OF ACRONYMS

AFED	**:**	Arab Forum for Environment and Development and Nuclear Safety
BCA	**:**	Singapore Building and Construction Authority
BMU	**:**	The German Federal Ministry for the Environment, Nature Conservation
BREEAM	**:**	Building Research Establishment Environmental Assessment Method
CBCSA	**:**	Green Building Council of South Africa
CFLs	**:**	Compact Fluorescent Lamps
CO_2	**:**	Carbon dioxide
EDPRS II	**:**	Economic Development and Poverty Reduction Strategy Ii
GBC	**:**	Green Building Council
GBCs:		Green Building Councils
GRIHA	**:**	Green Rating for Integrated Habitat Assessment
HVAC	**:**	Heating, Ventilation and Air Conditioning (HVAC)
IEA	:	International Energy Agency
IPPC	:	International Panel on Climate Change
LED	**:**	Light Emitting Diodes
LEED	**:**	Leadership in Energy and Environmental Design
LEED	**:**	Leadership in Energy and Environmental Design
MHC	:	McGraw-hill Construction
NSTC	:	National Science and Technology Council
REMA	**:**	Rwanda Environmental Management Authority
RHA	**:**	Rwanda Housing Authority
RWGBO	**:**	Rwanda Green Building Organization
SPSS	**:**	Statistical Package for Social Sciences
UK	**:**	United Kingdom
UNEP	**:**	United Nations Environnemental Program
UNEP- SBCI	**:**	Sustainable Buildings for Climate change Initiative
UN-HABITAT	**:**	United Nations Habitat
USA	:	United States of America
USGBC	:	United States Green Building Council

USLCI: United State Life Cycle Inventory

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ABSTRACT

The construction industry is one of the main energy consumers and emitters of greenhouse gases (GHG), generating about 23-40% of the world's greenhouse gas emissions. Recently, the construction industry has performed poorly in terms of environmental protection. The construction sector in developing countries is characterized by excessive resource consumption, resulting in habitat loss, land degradation, air and water pollution. This has exacerbated the global warming crisis and led to the development of green buildings. The objectives of this study is to analyze the level of awareness of green building concepts by building construction players between 2013 and 2018 in Kigali, to examine to which extent the green building concepts have been adopted in the Kigali City by the construction industry and to identify the factor impeding the implementation of green building concepts with the aim of identifying appropriate strategies for implementing these concepts.

The study was conducted using a questionnaire, interviews, and observations for data collection. It also reviewed secondary data from existing documents, including journals and books. The study findings showed that 90.2% of the players in construction industry participated in the recently constructed commercial buildings in Kigali and were aware of the green building concepts. However, only 17.9% of the concepts were incorporated into the building. By using the frequency rating scale, it appeared that the lack of enforcement of sustainable building policies, lack of education on green building concepts, lack of empowerment of stakeholders and lack of incentives from the government are the biggest obstacles practitioners face in the adopting of the concepts. Some strategies were recommended to promote uptake of the concepts include the development of sustainability checklist by local authority, availability of financial incentives like green loans, recognizing and certifying sustainable buildings as well as improved enforcement by local governments. The study concluded that administrative management and policies are needed to implement sustainable building concepts as well as introduction of incentives.

Keywords: Green buildings, Green Building concepts, Built environment and Sustainability

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

The building and construction sector play a significant role in the development of Africa and the welfare of its population. However, how a building is designed, how it is constructed and place it is located obviously affects the community, the users of the building and the environment (Choi, 2009).

Recently, the construction industry in terms of environmental protection performed poorly (Ofori, 2012). Construction sector in developing countries is characterized by excessive resource consumption and cause loss of habitats, land degradation, air and water pollution. The construction sector was identified as an energy-intensive sector and produce approximately 23-40% of the world's greenhouse gas emission (Gunnell, 2009).Buildings once again consume one-sixth of world's fresh water withdrawals, a quarter of its timber harvest and two-thirds of its material and energy flows (Stephen & Anthony, 2015).The structure of the building affects areas beyond their immediate locations including watersheds, air quality, transport patterns of communication among other things. Those serious negative environmental impacts of buildings have led to the new concept of 'Green Buildings' (Gunnell, 2009).

Green building (also called green construction or sustainable building) use less energy, water and natural resources than traditional buildings. They also reduce waste and provide a healthy living environment. In addition, they also have effective use of water, energy and efficient environmental protection. These buildings use renewable energy and recycled materials to make effective use of the landscape, improve indoor quality and maintain health and comfort. That's why in many countries governments had taken step to promote sustainable development through adopting green technology and green buildings construction ((Bernstein & Mandyck,2013).

The research conducted by McGraw-Hill Construction and United Technologies Climate, Controls, and Security, found that 51% of international firms, including engineers, architects, contractors, building consultants and building owners worldwide are focusing on sustainable design and construction as at least 60% of their projects were green by 2015, up from 28% in 2012 (Bernstein & Mandyck,2013).The most important part of the results is not limited to a particular part of the world or developed countries. The number of companies from 2012 to 2015 in South Africa will have more than 60% of their work becoming three times more green while in Germany, Norway and Brazil the number of company turning green will double.

According to the 2009 World Bank Development Report, in Africa there is only a Green Building Council (GBC) in South Africa but this is gradually changing with Mauritius, Egypt and Morocco undertaking the process of building their councils (Habitat, Green Building rating in Africa, 2010). Green building is increasing speedily all over the world as it was found to be long-term business opportunity but it is still at its infancy stage in Rwanda. So there is big query why commercial property developers are not adopting green building concepts and why still these concepts are at infancy stage in Rwanda.

Rwanda is looking for a sustainable way of reducing climate change and optimizing resources through the use of low-carbon development and green technologies (Nash, E. and Chrysostome Ngabitsinze, J., 2014). For this reason, the Rwanda Housing Authority (RHA) signed a Memorandum of Understanding (MoU) with Singapore Building and Construction Authority (BCA) on 7th September 2016 to promote the development of green buildings and cities in Rwanda. The purpose of the MoU in the construction sector is to identify and apply "green" construction requirements. Rwanda's policy documents(The national Green Growth and Climate Resilience Strategy (2011),The National Housing Policy (2015), Rwanda Building Control Regulations (2012) and Rwanda Environmental Policy (2003) link green building to the use of locally mined and produced, locally manufactured building materials, resource-saving technologies, low energy building standards and environmental protection measures.

1.1Statement of the problem

Although advantages of adopting green construction exist, they have received little attention in international global warming protocols and initiatives compared to industry and transport. The effective strategy to mitigate global climate change impacts and to minimize other negative environmental impacts must consider the environmental impacts of buildings (Gunnell, 2009).

The projects of developing commercial buildings has continued to grow within Kigali city. The government of Rwanda has understood the importance of safeguarding environment through sustainable building development as a really significant impact on resource consumption and on combating global warming effects and is looking at making commercial and residential buildings more energy efficient and sustainable (MININFRA, 2015). However, without appropriate measures emphasizing on the application of green building concepts, development of unsustainable buildings will not stop.

Even though the government has enacted and put in place various environmental laws, regulations and policies such as the National Green Growth and Climate Resilience Strategy by the Republic of Rwanda (2011) with aim of diversifying energy sources with low carbon energy grid and promoting green technology and resource efficient in urban development, The National Housing Policy (2015); Rwanda Building Control Regulations (2012) with initiative of promoting sustainable green building approach using local construction materials (compressed earth blocks), renewable energies (biogas, rain water, solar for a pilot house) and the

implementation and respect to Master Plans ; Rwanda Environmental Policy (2003) and EDPRS created to focus on the development of sustainable cities and villages among other priorities.

With enacted policies and regulations, the intention is to promote sustainability in the built environment and increase environmental awareness among professionals in design, planning, engineering and construction. However, the strategy used by government agencies in charge of housing and environment did not establish a practical mechanisms for implementing the green building concepts which is why green building is at infancy stage here in Rwanda. Therefore, there is a great question as to why commercial real estate developers do not adopt the concepts of green building and why these concepts are still in their infancy.This research aims to assess awareness level of Green Building Concepts among Kigali commercial property developers and stakeholders.

1.2 Objectives of the study

The main objective of the study is to assess awareness level of Green Building Concepts among Kigali commercial property developers & stakeholders, its benefits and to determine the challenges faced by developers and practitioners in the adoption of these concepts.

Sub-objectives:

1) To analyze the level of awareness of green building concepts by building construction players between 2013 and 2018 in Kigali.
2) To examine to which extent the green building concepts have been adopted in the Kigali City by the construction industry.
3) To identify the factor impeding the implementation of green building concepts.
4) To identify appropriate strategies for implementing green building concepts.

1.3 Research questions

1) What is the level of awareness of green building concepts by construction industry players between 2013 and 2018 in Kigali?
2) Has the building industry adopted the green building concepts in Kigali City between 2013 and 2018?
3) What factors impeding the implementation of the green building concepts?
4) What appropriate strategies can stakeholders adopt to increase the acceptance of green building concepts?

1.4 Justification of the study

Using the earth's limited resources in a sustainable manner while minimizing impacts on the environment is imperative and the concept of sustainable development can be used to develop sustainable construction. Rwanda's research on green building awareness and adoption has not yet been carried out. That is why, as a leader in knowledge dissemination and innovation, one of the most reasonable places researcher decided to start researching developing and implementing new green building technologies is our country Rwanda, especially in Kigali, which is a place with great potential commercial real estate development.

1.5 Significance of the study

The findings of this study are expected to create valuable knowledge in the field of built environment such as architecture, construction, engineering and real estate management as it is the first study assessing awareness level of green building concepts in Kigali commercial property development. This new knowledge forms a useful reading material to researchers and readers in general.

This study through its recommendations suggests ways of increasing the awareness in the adoption of green building concepts through mentality change and development of policy. It provides a basis for educating building construction participants in adopting green building concepts. Finally, the study influences the practice of consultants in the building industry in Rwanda. The use of specific findings will improve the quality of buildings in terms of sustainability.

1.6 Scope of the study

This study focused on buildings with 3 floors and above and constructed between 2013 and 2018 within 3 districts of Kigali City. Kigali City was selected because it had the largest number of commercial buildings which had been developed between year 2013 and 2018 after launching of Kigali City Master Plan 2013. Participants considered in this study were those who were involved in the design, construction and management of the completed commercial buildings within the study area. The study was limited to concepts of energy and water efficiencies, use of materials, choices of site, environmental quality and waste reduction. It was conducted between August 2017 and June 2018 through survey design, where opinion was sought from 127 respondents which included Architects, Quantity surveyors, Property Managers, Engineers and government officials by use of questionnaire which were reinforced by a check list.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter examines previous works related to this research. The review of literature examined research undertaken in relation to the concept of green buildings. It focused on assessing the level of awareness of the green building concept in Kigali's commercial real estate development.

2.1 Definition of terms

The following are the definition of key terms used in this study:

2.1.1 Green building

Green building refers to a structure using a process that is environmentally responsible and resource efficient throughout a building's life cycle (Vince Feltes, 2007 page 12).

2.1.2 Building

According to Cambridge (2014), commercial buildings used in this study are buildings used for general office space, professional office or administrative offices, hotels, apartments and retail shops .Cambridge also defined commercial building with more than half of its floor space is dedicated to commercial activities.

2.1.3 Green building concepts

The Green Building Concepts used in this study to describe strategies and technologies which are associated with five major elements of green building design namely sustainable sites, water efficiency, energy efficiency, indoor environmental quality and sustainable construction materials (Solomon, 2015, p. 6).

2.2 Defining "Green concepts" in commercial building

i. Defining green concepts

Many researches have been conducted on incorporation of green building technologies into commercial buildings from multiple perspectives. Many authors (Abidin, 2010; Thormark, 2006 and Cassedy, 2000) have studied the social, financial and environmental benefits in terms of the effects of green building design and energy efficiency of green concept through green architecture.

Green building is a concept of architectural design, material selection, construction technology and mechanical systems that reduces the direct and long-term impact on the environment and enhances the aesthetic and practical quality of living. Green buildings can also be cheaper if one

consider energy costs during the life of the building and may improve health and productivity in the structure.

Many definition of what a green building is or does exist. The ideal "green" project protects and restores habitats that are vital to life and becomes a net producer and exporter of resources, energy, materials and water, not a net consumer. The construction and service life of green buildings ensure the healthiest environment while representing the most effective and least destructive use of land, water, energy and resources (Governor Green Government Council, 2013). This requires close cooperation of the entire project stakeholders for all project stages (Yan Ji, 2006).The green building practice increases day to day and complements the classical building design concerns of durability, economy, utility and comfort (US Environmental Protection Agency,2009). Advances in technology and materials have made it possible to do things that were unimaginable a few years ago; designing buildings that improve the environment rather than damaging the environment (Water Furnace International, 2011). Integrated design approach that address site potential, water conservation, energy efficiency and renewable energy, as well as choice of building materials and indoor environmental quality is used for defining green buildings.

ii. History of green building concepts

In 2013, McGraw-hill Construction (MHC) released the study "Global Green Building Trends Smart Market Report", focusing on green buildings to identify differences in the green building market. Only 17 countries have official or emerging Green Building Councils (GBCs), and unfortunately Rwanda is not one of them. World Green Building (World GBC) is evolving to help the emerging GBC movement and the emerging GBC share experiences with other organizations.

By 2012, the global construction and economic situation was significantly different. After four years of reduced construction activity and a global economic recession, construction projects have shifted to developing countries, while developed countries face economic difficulties. Within the year 2012 GBCs have grown in more than 90 countries including South Africa. World cities are in the early stages of mobilizing global warming through green infrastructure solutions. Buildings account for about 40% of all energy consumption, electricity accounts for 70%, and carbon dioxide emissions account for 40% (Giorogetti, 2010).Hence, making buildings more energy efficient can be one of the fastest strategy to reduce negative environmental impacts and cut-off rising energy prices; most important is to reduce the overall impact of the built environment on human health and the natural environment by efficiently using water, energy and other resources, protecting occupants' health and the natural environment.

In the United States of America (USA) more than 30 states promote some level of energy efficient in residential construction (Reposa, 2009).This idea is highlighted by National Science

and Technology Council (NSTC) that by adopting sustainability concepts there is reduction in energy, operation and maintenance cost, reduced building related illness and reduced waste and pollution (Science and Technology Council,1995). California is the first state in the USA to enact green building codes and is obligated to set standards for the greening of residential and commercial buildings (Palmese, 2009). The California public utilities commission has set a goal for all new residential buildings, reaching a net zero energy standard (generating as much energy as possible) by 2020 and commercial buildings must reach the same target of commercial real estate by 2030.

A study done by Kats and his team at 40 California LEED certified buildings showed great success as follows: The buildings consumed 28% less than conventional buildings; water consumption was reduced by 50% of the 21 green buildings studied, construction waste was reduced by 17% of the 17 green buildings studied, construction waste was reduced by 8%, and 4 green buildings reduced construction waste by 75%. Operating and maintenance costs were reduced by 5%, an average of $3,000 per person per year (Urban Catalyst Associates, 2005)

In the city of Vancouver, research shows that buildings account for 30% of energy consumption, 28% of greenhouse gas emissions, 12% of portable water consumption and 30-40% of landfill wastes (Vancouver Economic Development Board, 2009). In 2005, Vancouver passed LEED certification for all citizen buildings.

Green building activities and trends in Africa are gradually being recognized. Studies have shown that green building practices are rapidly taking over in South Africa, and their green building companies are growing faster than any other part of the world (McGraw-Hill Construction, 2013). Green buildings in the South Africa is overseen by the South African green building council, launched in 2007. The committee developed the Green Star SA rating tool based on tools developed by the Australian green building council to provide the construction industry with an objective measurement for green buildings and recognition and reward for the environmental project in real estate industry. In South Africa, the construction industry accounts for 23% of greenhouse gas emissions, while the construction industry's main materials produce approximately 180,000 tons of carbon dioxide per year, accounting for approximately 4% of total CO2 emissions (CIDB, 2009). In 2012, 31% of construction companies stated that their work was green. Overall, 16% of South African companies report green levels in 2012 that are only eight times in three years (McGraw-Hill Construction, 2013). South Africa is one of the countries with a high level of reporting on green activity in the commercial market. The truth is that 40% of South African respondents expressed a desire to build new green commercial buildings (such as offices, retail stores, hotels). This shows that the growth of green buildings coincides with the increase in urbanization in South Africa. (CIDB, 2009)

The African green building rating conference (Habitat, African Green Building Ratings, 2010) confirms that green buildings have improved environmental performance over standard buildings and have features that make their occupants healthier. The meeting also showed that by reducing

the amount of energy, water and other resources, the operating costs of green buildings are always low and become valuable in the market.

The next sub-sections discussed various approaches to green concepts in regard to water and energy efficiencies, materials and waste, sustainable sites, integrated building design and other technologies that are applied to enhance sustainability in buildings.

2.2.1 Energy efficiency

Energy efficiency is a way to reduce the amount of energy needed to deliver products and services. Energy for building heating and cooling is the most energy-intensive activities, followed by power use for lighting and electrical appliances (Harvey, 2009), the greenhouse gas emissions from building energy use far exceed those from transportation.
The development of commercial and residential building workspaces in developing countries will drive an increase in building energy consumption. When considering the shape and orientation of buildings, passive solar design and passive design strategies for natural daylighting, most buildings can have energy efficiency levels that meet green standards (US Environmental Protection Agency, 2009).

Commercial buildings generate large amounts of carbon dioxide and sulfur dioxide by directly consuming electricity and heating fuel. Forecasts by the International Panel on Climate Change (IPPC) have shown that in high-growth scenarios, carbon dioxide emissions from buildings, including electricity, may increase from 8.6 billion tons in 2004 to 15.6 tons in 2030 (IPPC, 2007).
Due to the high energy use of the construction industry, developing countries will greatly increase carbon dioxide emissions.

According to the International Energy Agency (IEA), 2018 the energy efficiency of the construction industry and the decarbonization of the power industry can provide a large number of potential reductions.

a) Ways of reducing energy consumption

Previous studies have shown that there are many ways to reduce the energy consumption of buildings and that renewable materials and renewable energy sources have been used in buildings to make great use of energy (CIBSE, 2004).
Sub-section below discussed how reduction in energy consumption can be achieved in buildings.

i. Lighting

Lighting consumes 4% of energy consumption in homes and up to 30% in commercial buildings (Scott, 2009).The most popular light bulbs are halogen incandescent lamps, compact fluorescent lamps (CFLs) and light-emitting diodes (LEDs). Efficient illumination can be achieved by replacing inefficient incandescent bulbs with new bulb models with electrostatic ballasts and using daylighting (natural daylighting) for illumination. If your facility uses T12 fluorescent lamps, you can use modern T-8 and T-5 bulbs, efficient electronic ballasts and lighting controls to save energy.

Integrated sensors and controls and design circuits to turn off security light of the building independently from other interior lights when daylighting is sufficient on the periphery areas (Governors Green Government Council, 2013). Smart lighting and energy-efficient electronics are an easy way to save energy in commercial buildings. These devices are designed to be turned off when not in use. The smart light has a photoelectric sensor that reads natural light from the building and dims the light when there is plenty of natural light. Smart lights are usually equipped with motion sensors so that when there is no one in the room, the lights are automatically turned off (Rebecca Brownstone, 2004).

By optimizing the use of natural ventilation and the evaporative cooling actually used, the waste heat and/or solar regenerative desiccant can be greatly increased in dehumidification or absorption cooling energy efficiency. Power can also be reduced through improved light-emitting diodes (LEDs) or increased use of natural daylighting and the use of energy efficient appliances. Comprehensive architectural design and modification of building shape, orientation and materials can also reduce energy use (UNEP, CDM, and Building and Construction. 2008).

The biggest challenge for all energy production is its environmental impact. Solar energy is one of the most environmentally friendly power generation or heating sources. The solar panels can be attached to the roof of the building and the micro wind turbines can be connected to the walls to generate electricity from natural resources. Hot water is the largest component of the hotel's energy costs after heating and cooling (Cassedy, 2000). A well-designed water heating system will provide 50-80% of the hot water demand based on the geographical conditions of the building and the time of year. The solar water heating system generates hot water by thermal energy to produce hot water.

In Rwanda, Rwanda’s National Power Company (REG) launched an activity to distribute energy-efficient CFLs that effectively use energy efficiency to reduce electricity demand and thereby expand electricity supply. More than 200,000 Rwandan households have acquired compact fluorescent bulbs (CFLs) in World Bank-funded projects and carbon credits through UN’s mechanisms. High customer adoption rates and new energy-saving behaviors help end users save 64 GWh per year, valued at $14.5 million (World Bank, 2014).

The project also contributes to climate improvement and is the first institution in Rwanda to receive carbon credits – CDM (Clean Development Mechanism) certified emission reductions. It is estimated that about 24,000 tons of carbon dioxide will be reduced each year, which is equivalent to reducing the use of 5,000 cars (The World Bank, 2014).

ii. Temperature control

According to Scott, 2009. Heating, ventilation and air conditioning can account for most of the capital spent by building owners in Europe. Heating, ventilation and air conditioning account for 55% of the total energy consumption of residential buildings, and commercial buildings account for 35%. The heat produced by computers and other electronic equipments can be recycled to heat the building if the rooms are well designed. Heat pumps and heat exchangers can transfer heat from IT server rooms to other parts of a building or to heat up offices during cold seasons. This argument by Scott is advanced by Green economy that a more holistic approach to the design of buildings and their use also requires consideration of all energy related components including appliances (Rode, 2011).

In Rwanda and other developing countries, new green energy is being integrated in construction projects, and studies have shown that using energy-efficient lighting, ventilation and air conditioning can reduce energy use by 64% (Baker & Steemers, 1999). Other studies on energy consumption guidelines have shown that the introduction of natural ventilation can reduce the energy consumption of office buildings by 55-60% (CIBSE, 2004).

Siemens has proven through its energy efficiency solutions that each building now has a 20-30% energy efficiency boost by optimizing building management systems, lighting, heating and cooling systems, water and energy distribution and many more areas (Zhang, 2009). In local conditions, heating is not common even in cooling in hotels and some residential buildings. Although kerosene, charcoal and natural gas are commonly used for heating in most homes; commercial buildings prefer electric heating and lighting.

iii. Passive design strategies

Data base such as the U.S Life Cycle Inventory data base project have shown that buildings built primarily on wood contain less energy than buildings that are built mainly with brick, concrete or steel (USLCI, 2012). In order to reduce embedded energy, high performance windows and wall, ceiling and floor insulation increase the efficiency of the building envelop. Use of passive solar building designs are other strategies that designers have implemented to achieve energy efficiency. They orient windows, walls and places trees to obscure windows and roofs to maximize solar heat. In addition, the proper placement of the daylight window provides more natural light and reduces the need for electric lighting during the day (Rode, 2011).

According to Rode (towards a green economy, investing in energy and resource efficiency, 2011), passive design strategies can significantly impact building energy performance. These include shape, orientation, passive solar design and the use of natural daylighting. A study by Lamonica (Solar concetrators graces University Roof tops, 2011) said that passive technologies such as solar collectors can heat buildings' water to 200 degrees and save energy.

2.2.2 Building material, technologies and waste

Providing a healthy, comfortable and efficient indoor environment for occupants and visitors through architectural design, providing optimal conditions for indoor air quality, ventilation and thermal comfort, natural ventilation and daylighting, and effective control of the acoustic environment is the main advantages behind this green initiative Principles (Governor Green Government Committee, 2013).This green initiative can be achieved through the use of building materials, adhesives, sealants, finishes and furniture that do not contain, harbor, produce or release any particles or Gas pollutants, including volatile organic compounds that are harmful to human health and well-being.

According to the World Watch Institute, construction consumes 40% of the world's raw materials, gravel and sand, and 25% of wood each year (Roodman & Lenssen, 1995). It also accounts for 40% of the world's energy and 16% of water use per year. Choosing environmentally friendly building materials is one way to improve the performance of the building's environment; but environmental performance must be balanced with economic performance (Gottfried, 1996).Therefore, the contractor should determine the method of using high recycled materials in the building structure and finishes, such as mixed concrete using slag, fly ash, recycled concrete aggregate or other mixtures, to recycle content materials such as ceiling and floor tiles, carpeting, structural steel, sheathing and gypsum wallboard, carpet filler. Green contractors further explore the use of bio-based materials and finishes, such as various types of agricultural boards (sheaths and/or insulation boards made from agricultural waste and by-products, including straw, barley, soybeans, wheat ,sunflower shells and other materials) (Governor Green Government Council, 2013).

In Rwanda, builders and developers explain that they face a number of barriers which prevent them from delivering sustainable housing including restrictive government regulations that limit the use of alternative cheaper building materials. Local governments can develop procurement policies, contract specifications, building performance and building codes that support sustainable initiatives.

It further argues that careful position of openings and selecting building materials can minimize the requirement of lighting and heating (Ripin & Roger, 2012). Considering the efficiency in use of land and materials, green buildings offer opportunities to address the growing scarcity problems that many societies face due to use of ecosystem services in unsustainable way. It also

provides chances to deal with health and other environmental issues such as noise pollution, chemical contamination and hazardous waste in asbestos and paint (UNEP SBCI, 2010).

2.2.3 Water efficiency

Today, everybody seems to be talking about "sustainable "and "green". In terms of water conservation and water efficiency, these terms represent an extremely important trend affecting design professionals, building owners and managers, manufacturers, end users, water companies, governments, and water users. Studies proved that big office buildings can consume around 15,000 kiloliters of fresh water per year, and with the advent of waterless urinal technology, the need to flush a small amount of urine with 5-10 liters of perfect drinking water can be eliminated (Davidson, 2010).

The argument of Hauber and Barbara is supported by Stuart (2003) that commercial office buildings can make use of technological advances to improve water usage. Water can be saved through a combination of three important measures: First, the overall water consumption can be reduced by installing efficient fixtures, equipment and systems throughout the building. Secondly, where appropriate, rainwater and/or grey water should take precedence over drinking water for flushing, washing and irrigation purposes. Third, minimize the number of external water features and pools. Reuse water in the water and use the pool cover.

i) Water efficient fixtures and appliances.

Water efficiency is a key part of green building because buildings are the main users of the water supplies. In fact, the Leadership in Energy and Environmental Design (LEED) green building rating system has a water efficiency credit category that not only requires a minimum water savings, but is also rewards point for water saving building projects. The following are high efficiency plumbing fixtures and appliances :

- Installing water-saving devices, equipment and systems in your property is the first and most simple step to reduce water usage. The following products should be used: Faucet and shower that use water more efficiently
- Flush toilet and waterless urinals that use less water than traditional models.
- Dishwashers and washing machines that use water more efficiently
- Garden irrigation system, using available water, is the most efficient, eliminating unnecessary waste and evaporation.

Source: Stuart (2003).

ii) Rainwater reuse

Drinking water supplied through the main system has been treated to high standards to ensure safe drinking. This process involves the use of chemicals, disinfectants and a lot of energy. This is why it is important to preserve and replace its use in applications that do not require high quality water and alternatives such as rainwater. Rainwater tanks help protect drinking water resources and allow the use of tap water instead of flushing toilets, garden irrigation and hot water throughout the home. In addition, by keeping rainwater on site, the amount of rainwater and the amount of pollutants entering the local stream are reduced .Stuart (2003).

iii) Greywater reuse

Greywater is the waste water from washing machines, showers and laundry tanks. According to the law, water discharged from the kitchen and toilet is not allowed to enter the grey water system. greywater is not allowed for drinking purposes, but it can be used instead of tap water to flush toilets and gardens. Graywater can only be used in the commercial property when properly treated using gray water systems available on the market, which extend manually up to mechanical systems. The use of rainwater and grey water around buildings is an effective way to reduce tap water usage and billing. However, it is important to carefully consider the proper and safe place to apply rainwater and grey water. Stuart (2003).

2.2.4 Sustainable site design

Sustainable site design is a process that minimizes disturbances throughout the site and protects, restores or restores valuable habitats, green spaces and associated ecosystems that are essential for sustaining life. The design of buildings and sites affect the energy and water consumption. Green-planned sites will reduce the environmental impact of human activities, protect most existing natural vegetation, increase energy efficiency and reduce the amount of rain leaving the site (Environmental Science and Policy 763; UWGB, 2004). Sustainable sites reduce the amount of excavation and reduce construction costs and environmental impacts during construction. The strategies and technologies that can be used include refurbishing and reusing existing vacant sites and making effective use of the building space that is already in the operational stage.

City planners need to evaluate each site based on the location and orientation of the building and improvements to optimize passive solar, natural lighting, natural wind and ventilation. Reduce the urban heat island effect of site development footprint by maximizing the use of permeable surfaces and using light-colored roofs, paving and walkways. Provides natural shadows of trees and other landscape features for buildings and paved areas. Optimize on-site rainwater treatment and on-site groundwater recharge. Minimize the boundaries of the construction area, avoid unnecessary compaction of existing topsoil, and provide effective sedimentation and sludge control at all stages of on-site development and construction.Once the construction phase is completed, the landscape design is used to protect and restore the natural habitat and heritage of

the area, while emphasizing the use of indigenous, cold-resistant, drought-resistant trees, shrubs, plants and turf (Morrish, 2007).

2.2.5 Indoor environmental quality

The interior environment quality of commercial buildings is designed for a sustainable future by providing building occupants and visitors with a healthy, comfortable and efficient indoor environment. To improve the quality of the indoor environment, commercial buildings provide the best in indoor air quality, ventilation and heat. Comfortable conditions, natural ventilation and daylighting, and effective control of the acoustic environment are the main principles of this green initiative (Governor Green Government Council, 2013). This green initiative can be achieved through the use of building materials, adhesives, sealants, finishes and furniture that do not contain, harbor, produce or release any particles or Gas pollutants, including volatile organic compounds that are harmful to human health and well-being. The energy-certified ventilation system effectively removes or treats indoor contaminants while providing a sufficient amount of fresh cleaning air for all occupants and all areas of the commercial building.

These devices monitor indoor air conditions, including temperature, humidity, and carbon dioxide levels, so that building ventilation systems can respond when space conditions are out of optimal range. Designing building envelopes and environmental systems that not only handle air temperature and provide adequate ventilation, but also respect all environmental conditions that affect the thermal comfort and health of the human body, including the average radiant temperature of the indoor surface, indoor air humidity, indoor air flow rate, And indoor air temperature (Cohen-Rosenthal, 2000).

Today, green materials and advanced technologies can be applied to architectural design projects to reduce energy consumption. The architectural design of green buildings involves many professionals in different fields. There are many factors to consider, including climate, building shape, comfort, materials and systems, and health. In Rwanda, Rwanda's goal through a one-stop center is to promote the development of functional, healthy, aesthetically pleasing and environmentally pleasing housing.

2.3 Costs and benefits of green buildings

To assess the cost and benefit of any building, Green Building emphasizes the saving of water, energy and material resources in the construction and maintenance of buildings to reduce or eliminate adverse effects on the environment and occupants (Bordass, 2000). It can be emphasized that the implementation of the green building concept can reduce carbon emissions by 35%, water consumption by 40%, energy use by 50%, and solid waste by 70% (Jayalath, 2010). A Representation of green building elements are considered during the design phase (Bombugala et al., 2010).

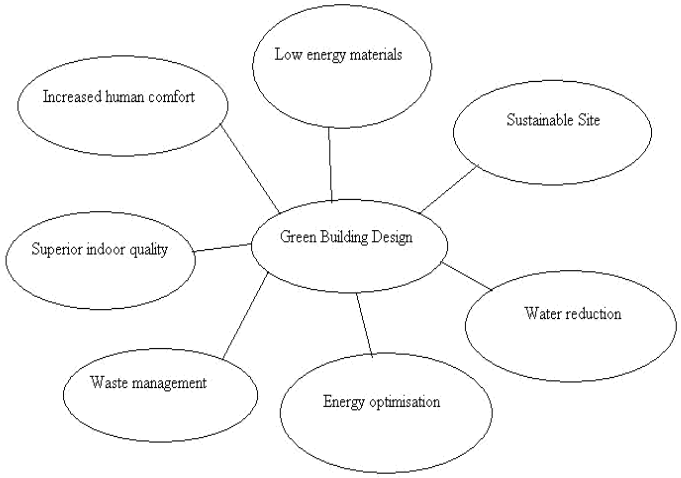


Figure 1: Components of sustainable building.

According to Jayalath (2010), the most critical issue about building environmentally friendly buildings is that modern technologies such as photovoltaics and new home appliances are often expensive. Construction costs for most green buildings have increased by 20-25%, but production has increased 10 times over the life expectancy of the building. Statistics shows that operation costs for green buildings are reduced by 30-40% (Jayalath, 2010).

The Holcim Foundation for Sustainable Construction also demonstrates that the initial cost of constructing a green factory building in Thulhiriya Sri Lanka is 30% greater than the cost of building a traditional factory building (Holcim Foundation for Sustainable Construction, 2009). But Morris (2007) pointed out that the cost of integrating sustainable design elements depends largely on factors such as building location, type of building, local climate, conditions of site, and project team knowledge with sustainable design.

Even though higher construction costs are a common view associated with green buildings (Lavy and Fernández-Solís, 2009), evidence from previous studies and reports highlights the benefits of green building (Deni Greene Consultancy Services, 1999; Cassidy, 2003; Kats, 2003; Hodges, 2005). Leadership in Energy and Environmental Design (LEED) also identifies six key fundamentals for sustainability/green building characteristics such as water efficiency, energy efficiency, sustainable site, sustainable materials and resources, indoor environmental quality and commissioning, operation and maintenance. Table 1 shows the social, economic and environmental benefits of sustainable construction under every principle (See Appendix 1). In addition, since the Sri Lanka Green Rating System is developed in accordance with LEED, the same format can be seen in GreenSL.

2.4 Key challenges of adopting green building concepts

The biggest challenges faced by developed and developing countries in pushing for green buildings is inadequate urban planning (Tessema et al, 2010). Most urban buildings are densely constructed and prevent air flow after construction. Planning sites are an important element of sustainable architecture because the construction process has a major impact on several sustainability aspects. In many African urban areas, including Rwanda, large areas of green space have been destroyed and trees have been demolished rather than integrated into the built environment (Tessema et al., 2010).

According to Adebayo (2000), buildings are common in many cities in Africa, but especially residential buildings have been carried out to occupy the entire plot. Vegetation has been destroyed and compaction has occurred, leading to environmental constraints. In many cases, the existing natural environment has been destroyed and cannot be repaired.

Other major challenges include the use of unsustainable building materials. Modern architecture in Africa is characterized by the use of less sustainable contemporary building materials and puts our sustainable building methods at risk. However, the construction of traditional African communities has been characterized by the use of local and natural materials that are cheap, accessible and less harmful to the environment (Tessema et al., 2010).

The problem associated with forests as they provide timber for the construction is another challenge. In addition, the construction materials industry in Africa contributes to deforestation when timber for construction is harvested without planting the replacement trees. Although forestry and timber harvesting are an important economic activity, it can only continue if it does not take measures to replace the harvested trees (Adebayo, 2000).

Waste especially during construction is disposed in water, rivers, pits and landfills nearby the construction site; this contributes to environmental degradation and there is extensive need to strengthen the waste management practice within the construction industry (Gottfried, 1996).

The construction sector and especially the use and operation of buildings consumes considerable quantities of energy. Therefore, there is a need to reduce energy demand, use renewable energy and increasing energy efficiency to reduce the burden on the built environment (Tessema et al, 2010).

2.5 Strategies of promoting green construction concepts

How to promote the widespread adoption of green building concepts in the construction process has always been a major concern for practitioners and scholars in the real estate industry (Hwang, 2017). There are different promotion strategies for green building concepts and practices adoption that have been discussed by previous researchers. For example, incentives and

government's co-funding, policies and regulations for green development and collaboration with research institutes and firms to study the major obstacles and benefits of green construction (Hwang, 2017).

In addition, expand the coverage of government incentives including development of a project management framework for green buildings, the use of green products and technologies, organize construction tours to educate the public about the benefits of green building, educate owners about the future benefits of green buildings, subsidy from government for research and development (R&D) in green building systems and management are identified strategies to promote green building adoption (Hwang,2012).

Furthermore, mandatory environmental regulations such as government and non-governmental organizations (NGO) requirements (eg green labeling schemes) and standards development (eg green specifications) have become important factors in promoting the successful adoption of green procurement in construction Project (Huang, 2012). Financial and market based incentives, green labeling and information dissemination, better information on green building cost and benefit information are also important in promoting green building concepts adoption (Darko, 2017).

Local authorities can promote a degree of adoption by developing a building sustainability checklist used during the construction permit approval process and can be considered during the issuance of occupation certificates. Improving law enforcement also requires appropriate education and training. According to Plessis (2005), education and training programs that focus on sustainable architecture should be an integral part of the architectural environment curriculum taught by learning institutions, and he further points out that it should be continuous professional development programs that provide certification systems for green building professionals.

Due to the emergence of green buildings, many green certificates, rating systems and labeling programs, such as the British Building Research Establishment Environmental Assessment Method ((BREEAM), the US Energy and Environmental Design Leadership (LEED), the Green Star Australia and Singapore Green Mark Program have been Introduced to effectively assess and measure the development practices of green buildings.

2.6 Criteria, evaluation and rating of green buildings

In order to assess the sustainability of buildings and construction activities, their performance should be measured and tested. Various standards and rating systems have been designed to provide performance indicators for building and building activities in terms of sustainability. The rating system has two main goals: to encourage the design of sustainable buildings and to help the assessment of the sustainability of buildings (Tessema, Taipale and Jan Bethge, 2010).

The main rating systems include the UK's widely used Environmental Assessment Method for Building Research Institutions (BREEAM), the LEED Energy and Environmental Design Leader developed by the US Green Building Council (USGBC), the Green Star developed by the Australian Green Building Council and the (GRIHA) the Green Rating for Integrated Habitat Assessment of India (Tessema, Taipale and Jan Bethge, 2010). There is no single measurement solution that provides a comprehensive and undisputed assessment of all sustainability aspects of a building (Roy&Gupta, 2008).

BREEM and LEED rating systems have started as a basic checklist of what to do, rather than what they should do, and have been further expanded to scoring points for some of the achievements.Areas of action are trying to combine the ecological, social and economic aspects of sustainability (Tessema, Taipale, & Jan Betts, 2010).

The Environmental aspects include standards related to energy use, waste management; water and material use, social aspects include accessibility of buildings, the well-being of occupants, and the protection of social and cultural values while economic standards are compatible with affordability and life Cycle cost (Tessema, Taipale, & Jan Bethge, 2010).

The LEED rating system addresses five environmental categories namely water efficiency, sustainable sites, energy efficiency, sustainable materials and resources, and indoor environmental quality as well as innovation and design categories (Cassidy, 2003). It also quantifies waste generation and renewable energy adoption, energy consumption, and provides a comprehensive assessment of the building's environmental performance over its life cycle. The four subcategories of GRIHA are site selection and planning, building planning and construction, building operations and maintenance and innovation (Tessema, Taipale and Jan Bethge, 2010).

On the other hand, BREEAM is used to measure the sustainability of new developed non-residential buildings in the UK. It has a two-stage evaluation process, including the design phase and later construction. Areas of assessment include water, energy, materials, waste, health and well-being, pollution transport and biodiversity (Breeam, 2013).

Often, the scale of assessment can vary between assessing the individual design characteristics of a building to assessing the sustainability of the entire community. Some of the systems places emphasis on a certain stage of the construction process or existing buildings, while others consider some specific issues such as energy, health and safety. In South Africa, the entire building is evaluated, taking into account how the building supports the development of sustainable peripheral systems (Tessema, Taipale and Jan Bethge, 2010).

According to UN-HABITAT (2010), almost all tools focus on similar environmental issues, with the difference being how the impacts are categorized in the tool, and the performance

benchmarks for each initiative are consistent with the rules of the tool, required documents and methods for evaluating buildings according to the plan. Most systems focus on energy, water, indoor environmental quality, management of ecological impacts of construction process, relationship between buildings and the physical environment, transportation impacts and building materials.

In many African countries including Rwanda, there exist no rating tools to evaluate buildings, rather government regulations determine minimum performance levels. More developed tools may not be related to the national background of tight construction labor market and shortage of building materials which increase construction costs. According to the UN Habitat Conference on the endorsement of Green Building Rating in Africa, these tools can be modified to adapt and improve these tools to create a positive transformation in the African built environment (UN Habitat, 2010).

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter describes research design, population, sample size and sampling techniques. It describes the instruments the researcher used in data collection and data gathering procedures, data processing and analysis which was employed in report writing.

3.1Research design

This study was used qualitative and quantitative modes of enquiries to assess awareness level of green building concepts in Kigali commercial property development. The study done by Mugenda (1999) shows that a combination of qualitative and quantitative methods is advantageous because they complement each other.

Qualitative methods provide in depth explanations while quantitative methods provide hard data. Therefore the findings from one method tends to validate the other. The primary data was obtained through observations, interview schedules and questionnaire addressed to different respondents from individuals who are involved in the design, construction and management of the buildings.

For quantitative method, five major elements of green building design namely sustainable sites, water conservation, energy, indoor environmental quality and conservation of materials determine the degree of awareness. The level of awareness and adoption was statistically analyzed on the sampled commercial buildings within Kigali city. These buildings being in the same geographical neighborhood and near similarity in design minimized sampling error.

3.2. Secondary data sources

This included information about green building concepts, both published and non-published information was used. Secondary information was used to provide a strong background to the study area by informing on the existing commercial design technologies. Secondary data was collected through review of past work, text books, from internet and journal articles.

3.2.1 Instruments of secondary data collection

Secondary data was collected by carrying out intensive library research and online internet resources. The review of literature was included looking at documents and journals on green building concepts and technologies and various case studies on adoption of green building concepts and technologies.

3.3 Field data collection

Primary data was sourced from observations, questionnaires and interviews. The primary data gathered from questionnaires directed to Architects, Quantity surveyors, Engineers and property managers. Further primary data were obtained from semi structured interviews with construction industry stakeholders from different government and non-government institutions in addition to observations made during inspections

3.3.1 Population

The population in this study comprises commercial buildings completed between year 2013 and year 2018. The commercial properties (hotels, supermarkets, apart-hotels, offices, and retail shops) with at least three floors and above developed between year 2013 and year 2018 are 44 (Data from Kigali City One Stop Center).

3.3.2. Questionnaire survey

Designed questionnaires were administered to various respondents/ stakeholders. These were answered in written form by various respondents including Architects, Engineers, Property managers and Quantity Surveyors behind the sampled buildings. A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. Structured questionnaires were used to collect population data (structure and sex ratio), education levels, energy sources, energy use, water efficiency, sustainable construction materials and site selection among other parameters.
This questionnaire was designed in the form of a likert scale with closed and open ended questions.

i. Sample size

According to Christensen (1991), research study has to consider a sample size proportional to the cost constraints and sample size should provide the ability to detect the independent variables effect. The data used in this study was collected from selected respondents from the target populations due to the factors of convenience and necessity.

To determine sample size, the researcher used the formula of Bouchard. This technique is used because developed commercial buildings with at least 3 floors and above are 44 (data from Kigali City One Stop Center), this population is less than 1,000,000 individuals and Bouchard formula should be used.

Bouchard's Formula:

$$nc = \frac{N * n}{N + n}$$

Where: N: Refers to the size of the population of the study commercial buildings with at least 3 floors and above =44

n: Refers to the sample size for the universe less than or equal to 1,000,000 i.e 96

n_c: Refers to the sample size

(Bouchard, Thomas J. 1988).

Thus,

$$nc = \frac{N * n}{N + n}$$

$$nc = \frac{44 * 96}{44 + 96} = 30.207 \approx 30\ Buildings$$

In this study a population size of 120 (n=120) respondents from 30 sampled buildings was used including; 30 Quantity Surveyors, 30 Architects, 30 Engineers, and 30 Property Managers respectively. Electrical, structural and Mechanical engineers were grouped together under Engineers and the respondents chose the category they fell into.

Table 1: Category of the participants of the study

Questionnaire		
PARTICIPANTS	***Respondents***	***Institution***
Architects	30	From 30 Sampled buildings
Quantity Surveyors	30	From 30 Sampled buildings
Property Managers	30	From 30 Sampled buildings
Engineers	30	From 30 Sampled buildings
Total participants	**120**	**From 30 Sampled buildings**

3.3.3. Semi-structured interview

According to Sir Francis Galton September (2012), a questionnaire is a research instrument including a series of questions for the reason of gathering information acquired from respondents and the researchers used it in primary data collection.

This method was preferred in this study because:

- It is cheap and does not require more effort from the questioner compared to telephone survey.
- Potential information can be collected from a large group of populations in short time.

- It gave the researcher standard answers that can easily enable him to analyze them easily

Schedules for interviews were prepared for stakeholders like Kigali City One stop center, Ministry on Infrastructure (MININFRA), Rwanda Housing Authority (RHA), Rwanda Environmental Management Authority, President of Institute of Engineers, The executive secretary of Rwanda Green Building Organization (RwGBO) and President of Rwanda Institute of Architects (RIA).

The interview was open ended and directed mainly to the experts at the level of assistant director and above.

Table 2:Semi-structured interview

PARTICIPANTS	***NUMBER***
Director Of Kigali City One Stop Center	1
Director in Charge of Housing and Human Settlement (MININFRA)	1
The executive secretary of Rwanda Green Building Organization (RwGBO)	1
Director in charge of facility and estate management (RHA)	1
Director of environmental and pollution control (REMA)	1
President of Institute of Engineers in Rwanda	1
President of Institute of Rwanda Institute of Architects (RIA)	1

3.3.4 Observations

According to Gerard Keegan (2009), the observation method is concerned with the planned recording; watching and analysis of observed behavior of the people you visited. Field observation is a method of data collection in which researchers observe within a specific research field. In this method inspection checklist was used as a tool for data gathering. An inspection checklist that defines green construction with a range of variables from minimal to complete incorporation of the elements was prepared to determine the degree of adoption. The incorporation of five environmental categories were checked during observation.

3.4 Data processing and analysis

3.4.1 Methods of data analysis and presentation

Qualitative and quantitative methods were incorporated to analyze the information gathered from the respondents through calculation of means and percentages. Respondents' expressions and perceptions, events, questionnaires, behavioral observation, records were analyzed. Percentages,

proportions and averages were employed to reach the conclusions. Data presentation was done through pie charts, histograms, tables and trend curves.

Processing and analysis involved:
i. Sorting data: This entailed ordering of data from questionnaire and other field records for the purpose of subsequent processing and analysis. The data were numbered and arranged systematically.
ii. Quality control check: This involved analyzing the validity and feasibility of data collected using various selective criteria.

3.5 Data validity and reliability

3.5.1 Validity
To check on data validity, the study relied on interview experts and use of an inspection checklist. Purposive sampling was used to obtain the desired sample size. Purposive face to face interviews and questionnaire was used to collect data in the area of study. All the research instruments were pretested before the actual study.

3.5.2 Reliability
The research assistants were trained prior to actual data collection to ensure they collect the desired data. For accuracy, the researcher worked with each group of assistants on different days. All research tools used were counterchecked by the researcher at the end of each day to correct mistakes and errors.

3.6 Data analysis methods
Data from interview schedules, questionnaires, and observation checklist and interview were firstly coded to facilitate the analysis of the research information. Responses from closed ended questions were assigned numerical values and analyzed quantitatively using mean item score and percentages whereas the open-ended questions were analyzed qualitatively. For closed ended questions, the data analysis involved the use of frequency count, percentages and ranking generated through the use of statistical program for social sciences (SPSS) version 16 to generate pie charts, histograms, tables and trend curves. Also Microsoft office excel was used to generate other charts and graphs for discussion.

CHAPTER FOUR

FINDINGS, RESULT ANALYSIS AND DISCUSSION

4.0 Introduction

This chapter introduces the analysis, interpretation and discussion of the data obtained from the administered questionnaire, conducted interviews and observations made to draw conclusions and recommendations. The specific areas of interest covered in the study included adoption of green building concepts, the extent of their adoption, the challenges hindering their acceptance and the strategies that can be adopted to promote their acceptance.

4.1 Socio-demographic variables of the study participants

	Count	**Percent**
Profession		
Architect	26	22.4
Quantity Surveyor	30	25.9
Property Manager	30	25.9
Engineer	30	25.9
Years of experience		
Below 5	26	22.4
6-10 years	37	31.9
11-15 years	21	18.1
16-20 years	17	14.7
Over 20 years	15	12.9

Table 3: Socio-demographic variables of the study participants

Source: Author (2018).

Of the 116 participants that completed the study survey, architects represented 22.4%; engineers were 25.9%; quantity surveyor 25.9% and property manager 25.9%. The highest proportion of participants (31.9%) in this study has professional experience of six to ten years

4.2 A Representative sampling

The figure below shows the location of 30 buildings surveyed in Kigali. There are 16 commercial buildings in the Gasabo district, 5 commercial buildings in the Kicukiro district and 9 commercial buildings in the Nyarugenge district.

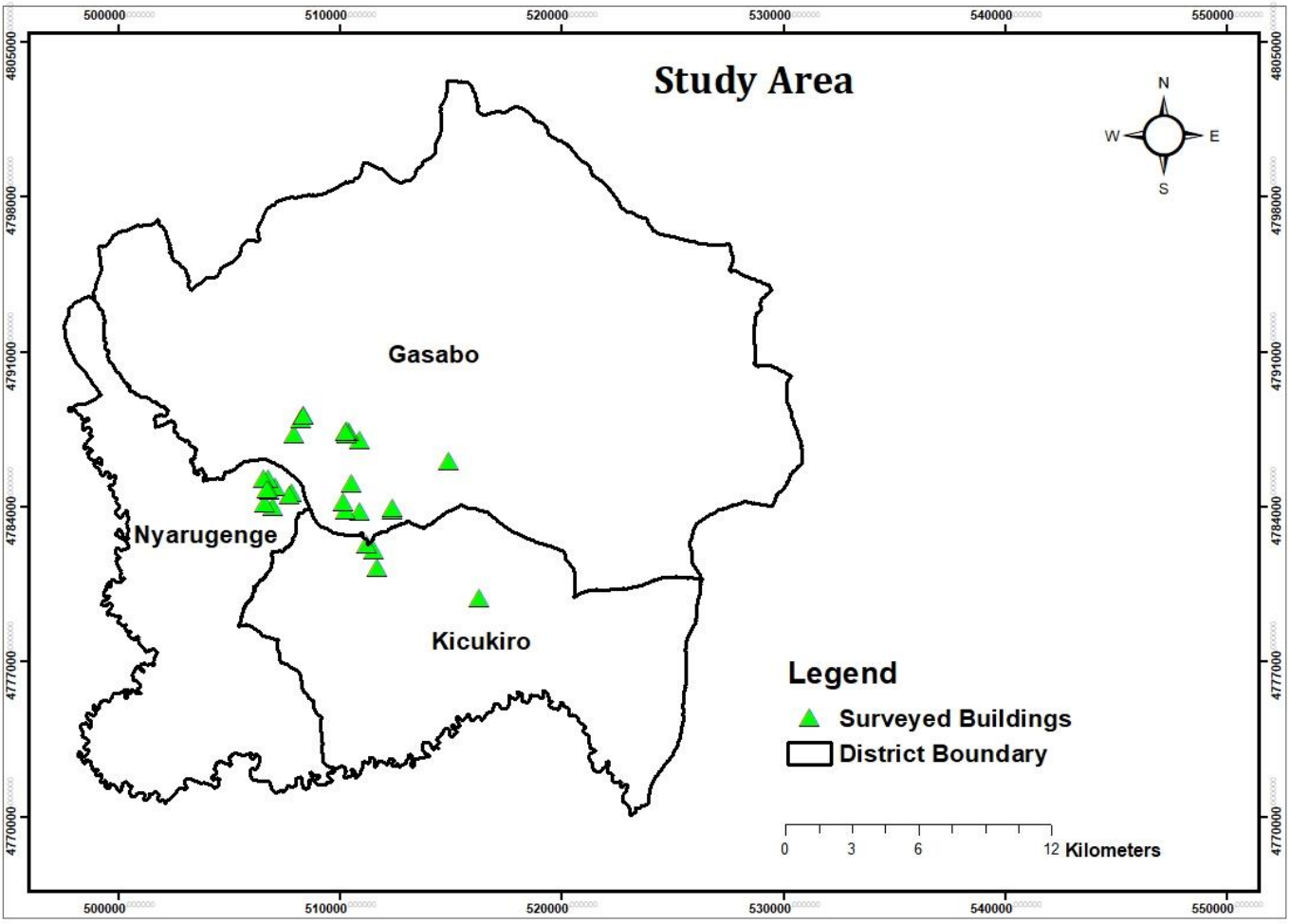


Figure 2: Surveyed commercial buildings in Kigali City

Source: Author (2018)

As shown above, a large number of commercial buildings were surveyed from Gasabo District, followed by the Nyarugenge district.

4.3 Awareness and incorporation of green building concepts in commercial building projects

The primary objective of the study was to analyze the level of awareness of green building concepts by building construction players between 2013 and 2018 in Kigali City to identify the challenges faced by practitioners and developers in the adopting of these concepts.To analyze the level of awareness of green building concepts by building construction players, the green building concepts were grouped into five environmental categories namely water efficiency and

conservation, energy efficiency, choice of site, material and environmental quality. The practitioners were initially asked if they were aware of the green building concepts and whether they had incorporated them in their projects in the last 5 years (2013 – 2018). Below are their responses on both awareness and incorporation of the concepts.

4.3.1 The level of awareness of green building concepts by building construction players

The study showed that the professional and the practitioners in the sampled buildings were aware of the green building concepts under the five environmental categories. Water efficiency had the highest percentage of awareness (98.3%), energy efficiency accounted for 96.6%, the use of sustainable site practices took 94.8%, indoor environmental quality occupied 81.9% whereas awareness on use of sustainable material was 79.3%, and the average of awareness is 90.2%. This average awareness is high, as Rwanda's construction industry participants know that creating a sustainable future depends on knowledge and people's participation in safeguarding of environment. The construction industry in Rwanda is familiar with the impacts of construction activities on our climate.

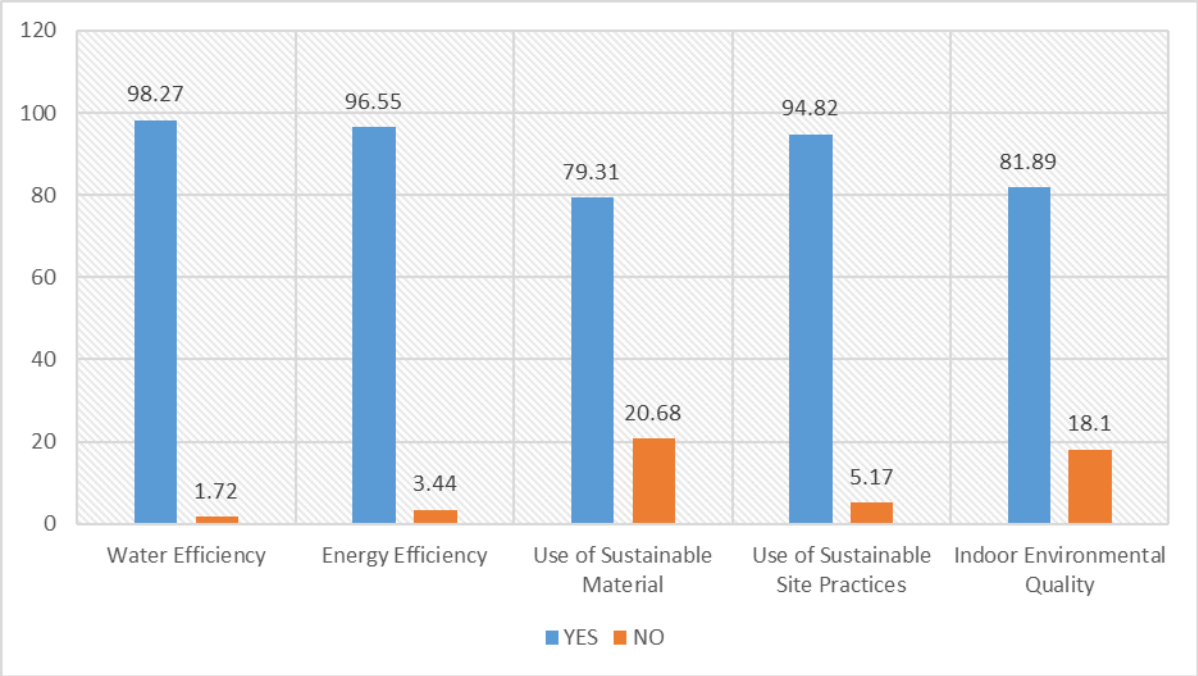


Figure 3: Awareness of the green building concepts by building construction players

Source: Author (2018)

4.3.2 Incorporation of some green building concepts in commercial building projects

The study further showed that 100% of the consultants and the practitioners in these commercial buildings had incorporated some of the concepts in the projects they were involved in during the last 5 years. This was further confirmed during interviews with the Executive Secretary of Rwanda Green Building Organization (RwGBO) and the Director of Kigali City One Stop

Center who indicated that practitioners were aware and had incorporated the green building concepts in their commercial building projects. In addition to interviews, by observations it appears that various concepts such as rainwater harvesting, water efficient fixtures, use of renewable sources of energy, provision of adequate ventilation, thermal and sound control among others had been incorporated in some commercial buildings. The high scores in both awareness and incorporation of the concepts shows that the consultants and practitioners were in a position to indicate the extent they had incorporated the green building concepts in the commercial building projects.

4.4 Adoption of green building concepts

The second objective of the study was to examine the extent to which the construction industry adopted the concepts of green building in Kigali.To examine the extent of adoption, it was important to find out which among the five environmental categories such as water efficiency and conservation, energy efficiency, choice of site, material and environmental quality had been applied in the projects during the last 5 years. The study found that consultants and practitioners had engaged in some level of green activities in all the environmental categories.

The study revealed that 34.48 % of the respondents had applied water and conservation concepts to a great extent, 8.6% had applied energy efficiency concepts to a great extent, 0% had applied Sustainable Materials concepts to a great extent, 39.65% had applied sustainable site practices concepts to a great extent and 6.89% had applied the concept of indoor environmental quality to a great extent. The average extent to which the concepts had been incorporated was 17.9%.

The level of incorporation of each of the five environmental categories is discussed below.

4.4.1 Incorporation of the environmental categories

The study established that certain concepts in all the five environmental categories had been applied in the completed commercial buildings. Concepts in the category of water and energy efficiency had been applied mostly with a score of 98.3% and 97.4% respectively. Water and energy efficiencies attracted high scores perhaps because of their daily usage in buildings which calls for monitoring besides the high bills associated with their provision as indicated during the interviews. The use of sustainable site practices had been applied with a score of 96.6%. This is because commercial building projects should respect the Kigali City master plan and construction industry players like architects, were advised to ensure that the plans they submit to the One Stop Centre on behalf of their clients, are up to the required standards. In addition, time will be lost if the plans are rejected on basis of non-compliance to the master plan or in case it is found that they are simply not up to the required standards.

Indoor environmental quality represented 95.7%. The explanation might be because construction industry players are familiar that improved indoor environmental quality can improve work performance and health. The use of sustainable material is low (24.1%) because there is a lack of

awareness and knowledge on sustainability of construction materials by construction industry players. The interview indicated that, the lack of awareness and knowledge could be due to the lack of expressed interest from developers, the high cost of sustainable building materials and long payback periods from sustainable practices, which seems to suggest that construction companies are reluctant to invest in environmental, economic and socially sustainable designs/projects in Rwanda.

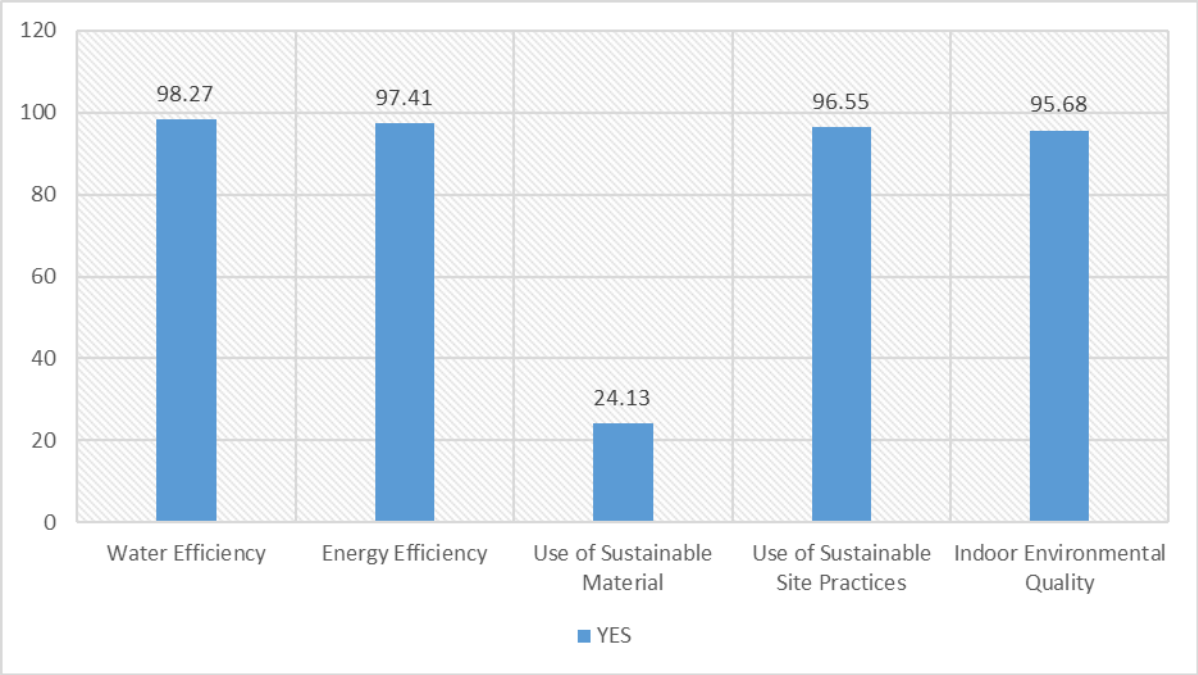


Figure 4: Respondents applied five environmental categories

Source: Author (2018)

4.4.2 Adoption of water efficiency and conservation concepts

The study sought to find out the extent to which water efficiency and conservation concepts had been incorporated in Kigali commercial buildings. It was revealed that the concepts of water and conservation had been applied to a moderate extent of 51.7%. About 34.5% of respondents indicated that the concept was applied to a great extent; 8.6% was applied to a very great extent and only 5.2% was applied to a little extent. These results indicate that the level of incorporation of efficiency and conservation concept in the sampled buildings is high. The Rwandan government makes steady progress in improving access to safe water and sanitation by strengthening efficient and productive investments, sustainable management of its water resources. The Government of Rwanda promotes the use of rainwater harvesting as a key output under water management policies (MINIRENA, 2011).

It was observed that in the 30 sample buildings, only apartments had installed water sub meters. The reason is that the use of water sub meters had been incorporated only in apartments is that tenants prefer to have their own water bills for purposes of monitoring and control than paying a fixed amount incorporated in service charge. AFED (2005) designated in their study that water sub meter is one of the ways that are used to monitor use of water in commercial buildings. The sub-metering provides the incentive for cost savings which can be realized by allowing water users to be aware of their consumption habits and linking their water bills to actual consumption rates (AFED, 2005).

Figure 5 shows the extent to which this concept had been incorporated in the commercial buildings.

Among the water efficiency and conservation concepts in Table 4, it was revealed that the use of rain water harvesting tanks had been incorporated to a very great extent by 37.1% of respondents, water recycling had been incorporated to little extent by 50% of respondents, water efficient fixtures had been incorporated to moderate extent by 62.1% of respondents while the use of water sub meters had been incorporated to a little extent by 13.8% of respondents. Reduced city water for sewage had been incorporated to a little extent by 8.6% whereas water waste reduction had been incorporated to a little extent (22.4%). The great majority (91.4% of respondents) use water-saving toilets, faucets and shower heads to reduce water bills from Water and Sanitation Corporation (WASAC). This was observed during inspections of the buildings and it was noted that Water-Efficient Plumbing had been used in 27 buildings.

One possible reason why rainwater-harvesting tanks had been incorporated to a very great extent is that in recent years, the Ministry of Natural Resources (MINIRENA) and its partners carried out different activities in effort to develop rainwater harvesting. The sensitization work on behalf of Rwanda Natural Resource Authority (RNRA) is done by the Rainwater Harvesting Project, which aims to improve livelihoods and to reduce surface runoff-overflow that causes erosion. In order to improve and sustain the development of rainwater harvesting, the National Rain Water Harvesting Strategy has been developed and a National Program is being developed.

The rainwater harvesting loan scheme, is a new Public Private Partnership operation initiated by the Ministry of Natural Resources in order to facilitate local communities to get financial support in the use of rain water harvesting systems at low interest rates compared to other types of loans (MINIRENA, 2016). The reason given as to why respondents had incorporated waste water treatment plants to a little extent was the lack of space mostly for retail shops and offices, the cost of construction which is high and planned maintenance cost which is constraint. Waste water was directed towards the septic tanks or disposed as runoff.

According to the Rwanda Environmental Management Authority (REMA), more than 75% of the water consumed eventually becomes waste, but it can be recycled and reused to reduce environmental stress and reduce water bills. In particular, human waste, including solid and

liquid waste, can be processed and converted into usable water to ensure zero waste and sustainable environmental solutions. The Director of Rwanda Environment Management Authority stated that the lack of waste water treatment can lead to environmental degradation, high costs and may lead to some water-related diseases.

The researcher's observation is that treated wastewater in most cases here in Kigali is used for landscaping, irrigation, cleaning among other uses. It was observed that the majority of the sampled buildings (retail shops, offices) did not leave open spaces for landscaping. One of the reasons why recycling of water was incorporated to a little extent was because there was probably no landscaping that influences property owner to recycle.

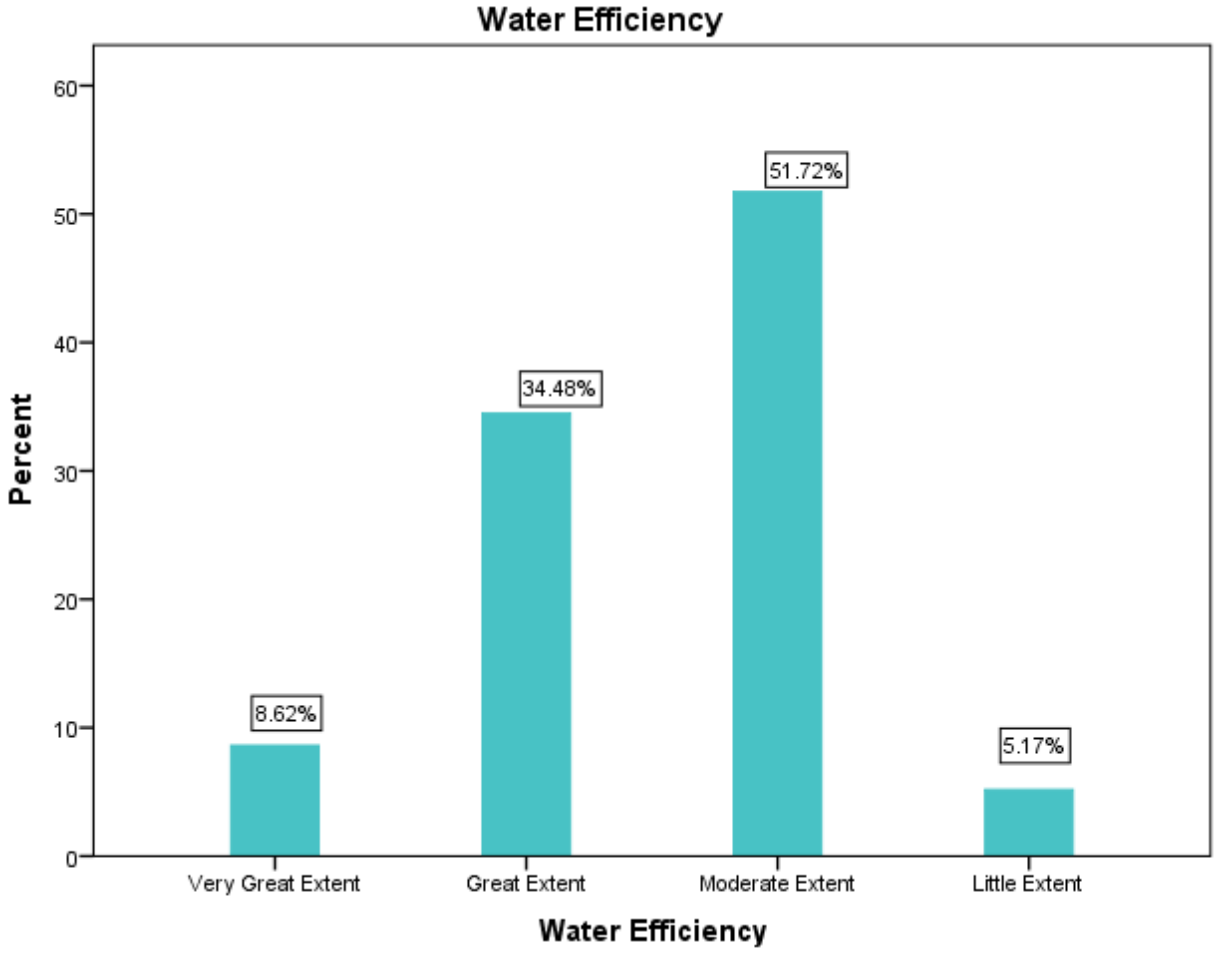


Figure 5: Water efficiency and management concept

WATER EFFICIENCY AND CONSERVATION	Not at all	Little	Moderate	Great	Very Great
Rain Water Harvesting	0%	17.2%	18.1%	27.6%	37.1%
Water recycling	30.2%	50%	19.8%	0%	0%
Water efficient Fixtures	8.6%	13.8%	62.1%	15.5%	0%
Water supply sub meters	84.5%	13.8%	1.7%	0%	0%
Reduced city water for sewage	91.4%	8.6%	0%	0%	0%
Water waste reduction	67.2%	22.4%	10.3%	0%	0%
Innovative waste water use	56.9%	43.1%	0%	0%	0%

Table 4: Extent of incorporation of water efficiency & conservation concepts

Source: Author (2018)

4.4.3 Adoption of sustainable sites

The study sought to establish the extent to which the concept of sustainable site had been incorporated in Kigali commercial buildings. It was revealed that the concepts had been applied to a moderate extent (46.6% of respondents); about 39.7% of the respondents indicated that they had applied the concept to a great extent, 7.8% to a little extent whereas only 6% had applied the concept to a very great extent. Figure 6 and table 5 shows the extent to which the concept of sustainable site had been incorporated in the commercial buildings.

These findings indicate that adherence to the Kigali City Master Plan requirements by site landscaping, and preservation of existing vegetation and management of storm water are concepts which are considered either during design and construction or during occupation of commercial buildings, contrasting with findings by Tessema, et al (2010) and Adebayo (2000). Adebayo (2000) believes that many urban areas in Africa, especially cities, have built buildings that occupy the entire site, completely ignoring the natural environment. The reason behind this is that the Rwandan government made considerable efforts to encourage green growth and sustainable development by the Ministry of Natural Resources. This is in line with the concept of

a green city, and its practice shows that the city of Kigali must have urban forests, vegetation, proper waste management and the collection of rainwater to curb flooding.

In the four concepts of sustainable site, the study revealed that adherence to local zoning requirements was the most incorporated concept with a very great extent by 74.1% of respondents whereas preservation of existing vegetation was not incorporated by 96.5% of respondents. The incorporation of the concept of adherence to local zoning requirements to a great extent was achieved due to efforts made by the city of Kigali in the implementation of Kigali City Master Plan 2013. According to the Kigali city one stop center, construction permit can not be approved if the design has not been done according to its intended use for the particular zoning code. After deliverance of construction permit, Kigali one stop center visit construction site to look if approved plans are the same as the ongoing facility.

Zoning plans are often used in regulating the types of land uses, the intensity of development, and the setting and height of buildings on plots. They therefore serve as operational planning tool to guide the development of land in a rational and systematic fashion. The Kigali City Zoning Plan was envisioned to provide landowners and developers with the kind of development that may be permitted on any particular plot. The zoning plan consists of a zoning map and a set of zoning regulations. The zoning map provides information on the specific zoning districts within the planning area based on the predominant land uses, and the anticipated intensity and building height for that area.

The study indicates that the majority of respondents (48.2%) have applied site landscaping to a little extent and only 3.4% of respondents have applied the concept of preservation of existing vegetation. The interview specified that the developers want to maximize the site for perceived 'higher returns' and the developers found themselves with no open spaces to landscape nor to preserve existing vegetation.

Adebayo (2000) believes that in many urban areas of Africa, especially in cities, construction of buildings, but especially residential buildings, have taken up the entire site.These findings and observations are similar to studies undertaken by Tessema, et al.(2010) who argue that the occupation of entire site other than limiting landscaping, also interfere with ventilation and air movement. In relation to the management of storm water, this was incorporated to a little extent (15.5% of respondents), the interviews show that practitioners understood the benefits of managing rainwater (storm water) but indicated that successful affordable storm water management requires a long-term coordinated approach to integrate best practice as well as community and business engagement and education programs.

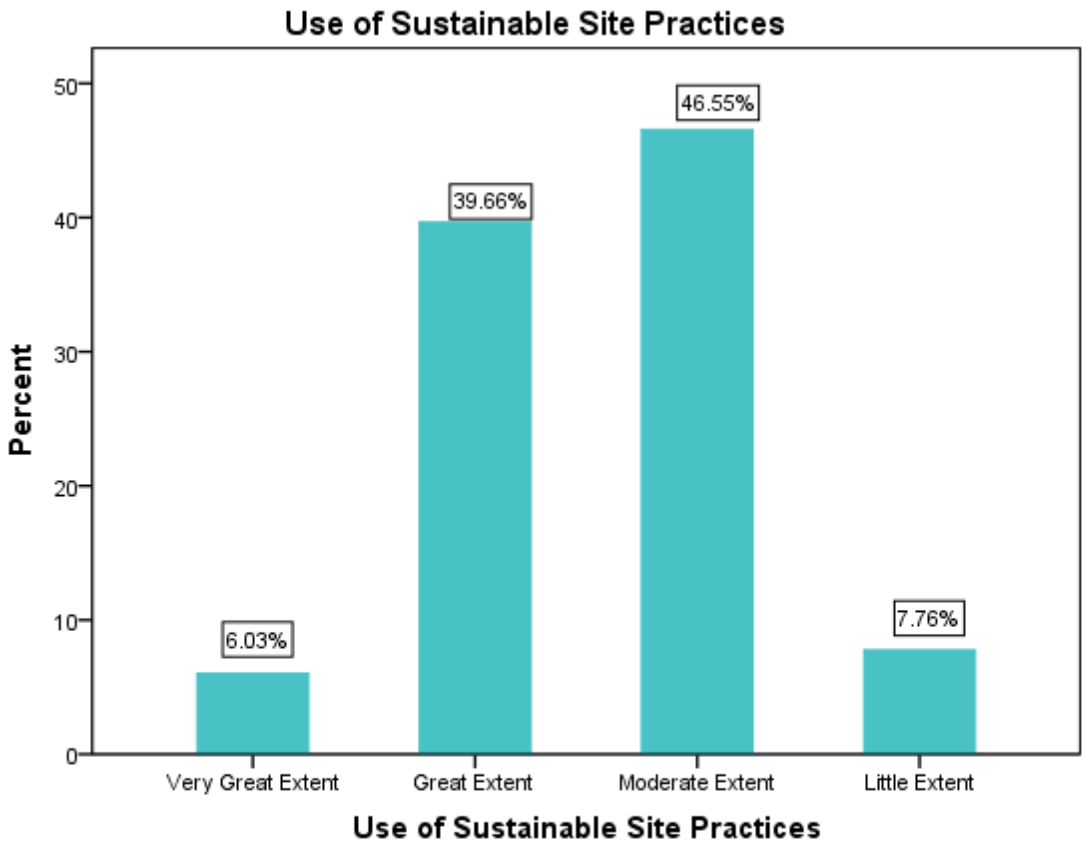


Figure 6: The incorporation of sustainable site in the commercial buildings

CHOICE OF SITE	Not at all	Little	Moderate	Great	Very Great
Adherence to Local zoning requirements	0%	0%	6.0%	19.8%	74.1%
Preservation of existing vegetation.	96.6%	3.4%	0%	0%	0%
Site Landscaping	19.8%	48.3%	19.0%	12.9%	0%
Management of storm water	84.5%	15.5%	0%	0%	0%

Table 5: Extent of adoption of Sustainable sites

Source: Author (2018)

4.4.4 Adoption of energy efficiency

The study sought to establish the extent to which energy efficiency concepts had been incorporated in commercial buildings. It was revealed that energy efficiency concepts had been applied to a little extent. Approximately, 63.8% of the respondents indicated that they had applied the concept to a little extent; 21.6 % to a moderate extent; 8.6 % to a great extent, whereas only 6.0% had not adopted this concept. Figure 8 shows the extent to which the energy efficiency had been incorporated in the commercial buildings. In the concepts, the study revealed that the use of alternative sources of energy such as gas, charcoal, was applied to a little extent (50.86%). Cooking gas could possibly be attributed to reducing electricity bills while charcoal was preferred to prepare meat Skewers (brochette).

The use of solar energy was adopted to a moderate level (63.8% of respondents). This observation demonstrated that solar water heaters are used by all sampled hotels and apartment buildings, the reason behind is that Rwanda sets rules for solar water heaters market and is running green energy campaigns in order to reduce the heavy dependency on thermal electricity. The government has introduced new subsidies to keep some electricity consumers off the main grid in addition to offering tax exemptions. The government is meeting 25 % of the cost of imported solar power water heaters. The interview with the Executive Secretary of Rwanda Green Building Organization and stakeholders indicate that electric energy is still the most reliable source of energy compared to other sources in Kigali Commercial Buildings.

Related researches indicate that backup generators are only used during black outs to avoid extra 'peak demand 'whereas charcoal and gas are commonly used in homes and hotels. The findings that the use of alternative sources of energy is applied to a little extent therefore corresponds with other previous researches that commercial buildings rarely use other alternative sources of energy other than electricity especially because of complex demand for cooling, heating and lighting (Brown, 2000).

The highest percentage of respondents (48.27%) adopted the energy conservation measures concept largely while only 3.4 % of respondents did not apply the concept. Generally, this concept was the most applied among others. One possible suggestion for this result is that individual tenants monitor their consumptions, so the bills are not included in the rental amount and this lowers their consumption and bills by using pre-paid cash power meter. Past studies suggest that conservation measures like smart meter that monitors how energy is used and light control sensors are measures that can go a long way to conserve energy (Scott, 2009).

Even though the study revealed the use of pre-paid cash power meters in the buildings was to a great extent, it was noted that there was no particular metering on the equipment and other electronic devices in the buildings. Pre-paid cash power is beneficial to both energy consumers and the utility companies because it helps the users to consume energy in a more efficient manner, and it improves the management of their budget, while allowing the firms to reduce their financial costs, as well as the costs of operation and bad debts. These findings are also in line with the observation made during the study where it was noted that there was use of compact fluorescent lamps (CFLs) for lighting spaces as opposed to incandescent lamps. CFLs as noted in the literature review are known to consume less electricity than the ordinary lamps.
The use of day lighting was applied to a moderate extent (38.7% of respondents). The reason is that the stakeholders in construction industry adopt daylighting concept by placing windows, curtain walls and other openings so that natural lighting from the sun can provide optimal internal lighting. Particular attention is given to day lighting while designing a building with the aim of maximizing the visual comfort and the reduction of energy usage.

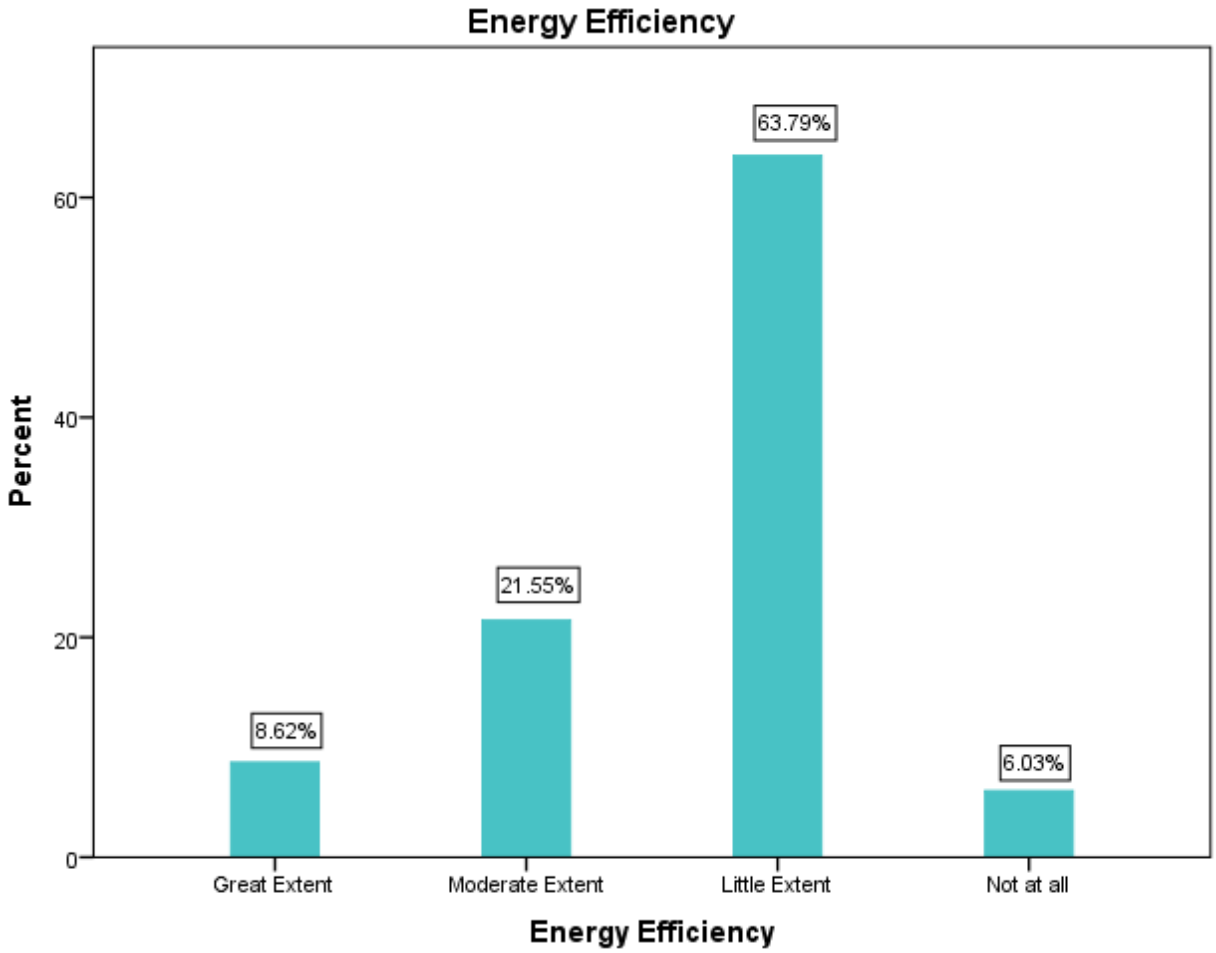


Figure 7: The incorporation of energy efficiency in the commercial buildings.

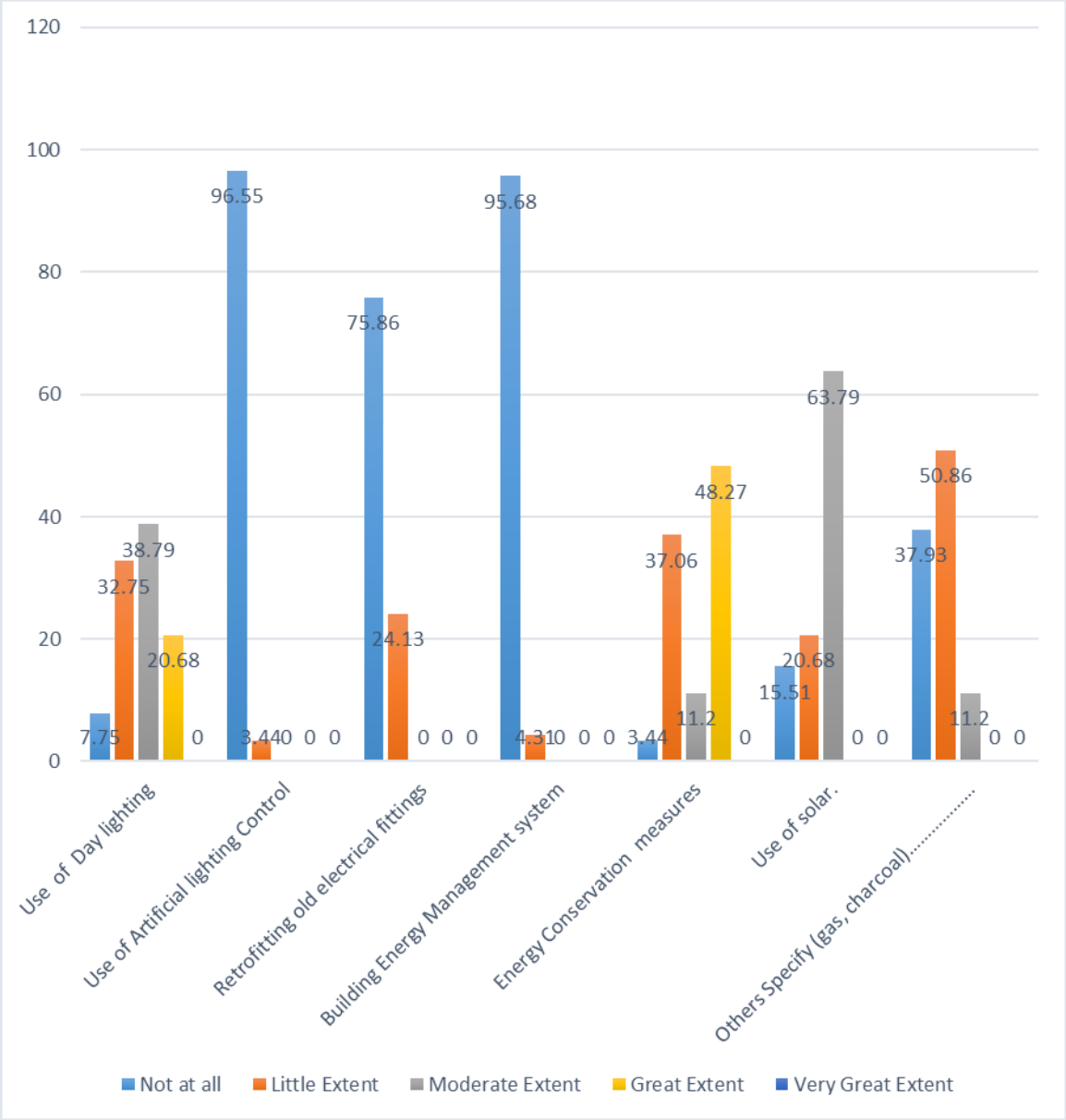


Figure 8: Extent of adoption of Energy Efficiency

Source: Author (2018)

4.4.5 Adoption of sustainable materials

The study revealed that the concept of sustainable materials had been applied to a little extent (56.9 % of respondents) , about 13.8% used sustainable materials to a moderate extent whereas 29.3% had not applied the concepts of sustainable construction materials. Figure 9 shows the extent to which the concept of sustainable site had been incorporated in the commercial buildings. The results indicate that practitioners do not consider the use of sustainable materials in their projects (0% had applied sustainable materials to a very great extent). The concepts under sustainable materials, which were considered in the study, included the use of local

materials and components, use of recycled materials and the use of materials with low environmental impact.

Figure 9 and table 6 indicate that the use of materials with low environmental impact was the most incorporated concept under sustainable materials with a percentage of 44.8% of respondents followed by the use of local materials and components with a percentage of 12.9% of respondents. The use of materials that can be reused or recycled after the building life had been incorporated to the lowest level (7.7% of respondents had applied the concept to the great extent). The incorporation of materials with low impact to the environmental could be attributed to the fact that there has been introduction of various environmental laws under authorities like Kigali City One Stop Center and REMA that require practitioners to conduct environmental impact assessments before project development as discovered during the interviews. After noticing that asbestos containing materials continue to cause diseases for workers and the general population, the prohibition of asbestos for roofing restricts the practitioners to use only acceptable materials for the projects to be approved by Rwanda Standards Board.

Recycling should be considered as a priority if we want to preserve our planet Earth for future generations. This is primarily because recycling is good for the environment, since new products are made from old ones. However, this study revealed that the use of recycled material was least applied in the commercial buildings and therefore corroborate with previous studies reviewed in the literature that recycling of building materials is a relatively new concept and has only been assessed in a few studies (Rode, 2011). Despite these findings however, it was observed that a number of recyclable materials such as aluminum, and timber were used in the construction of these buildings.

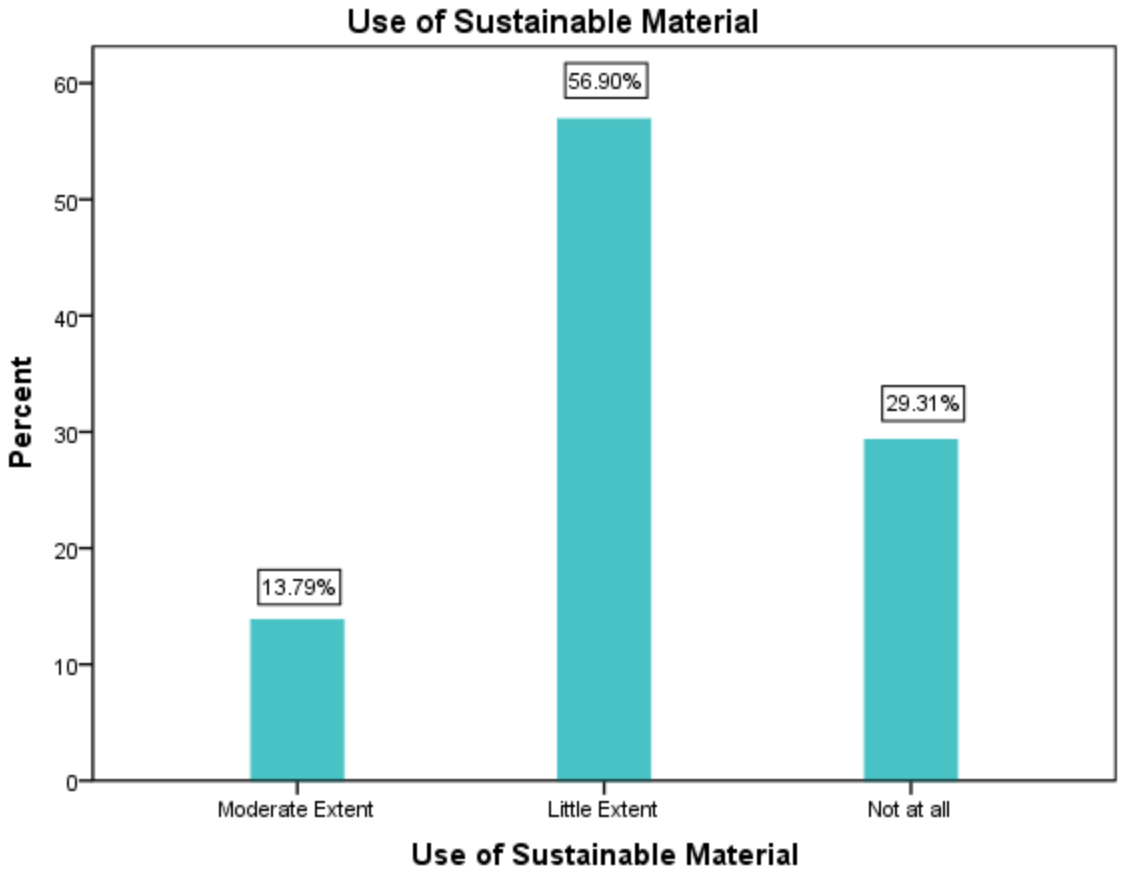


Figure 9: Extent of adoption of sustainable materials

Sustainable Construction Materials	Not at all	Little	moderate	Great	Very great extent
Use of local materials.(No imports)& Use of local components	0%	55.2%	31.9%	12.9%	0%
Use of materials that can be reused or recycled after the building life; Use of Low Toxic material	54.3%	24.1%	13.8%	7.8%	0%
Use of materials with low environmental impact.	0%	22.4%	32.8%	44.8%	0%

Table 6: The incorporation of sustainable site.

Source: Author (2018)

4.4.6 Adoption of environmental quality practices

Six concepts under environmental quality which included ventilation to spaces, use of thermal control units, noise control, and provision of smoking areas, use of low emitting paints and use of low emitting finishes were considered in this study. It was revealed that the concept of environmental quality had been applied to a little extent. Figure 10 shows that 70.7% of the respondents indicated that they had applied the concept to a little extent; 22.4% to a moderate extent whereas 6.9% used the concept to a great extent. These results indicate that only concepts, which had adverse effect like paint (31.03% of respondents), were adopted by the stakeholders at a great extent.

In the six concepts under environmental quality the study revealed that provision of smoking areas was the least applied concept as 84.4% of respondents did not apply the concept whereas the use of low emitting paints and adhesive was incorporated the most as 31.03% of respondents had adopted the concept to a great extent as demonstrated by Figure 11.

Incorporating smoking areas into buildings is a new concept in Rwanda's building codes. Rwanda is welcomed for the implementation of the tobacco control law in line with the World Health Organization (WHO) framework. The Rwandan government has stopped tobacco advertising, promotion and sponsorship to save many lives that are prone to tobacco deaths. The Rwandan government has not made significant efforts for construction industry practitioners to force them to incorporate smoking areas into the building design, and most toilet areas are used as smoking areas.

Concerning paint, it is a commonly used in finishing in commercial buildings especially the internal surfaces as observed during the study and therefore practitioners would be slow to use products, which are harmful to users. Other than being a common finish, manufacturers would lose out in the market with products that do not meet the standards.

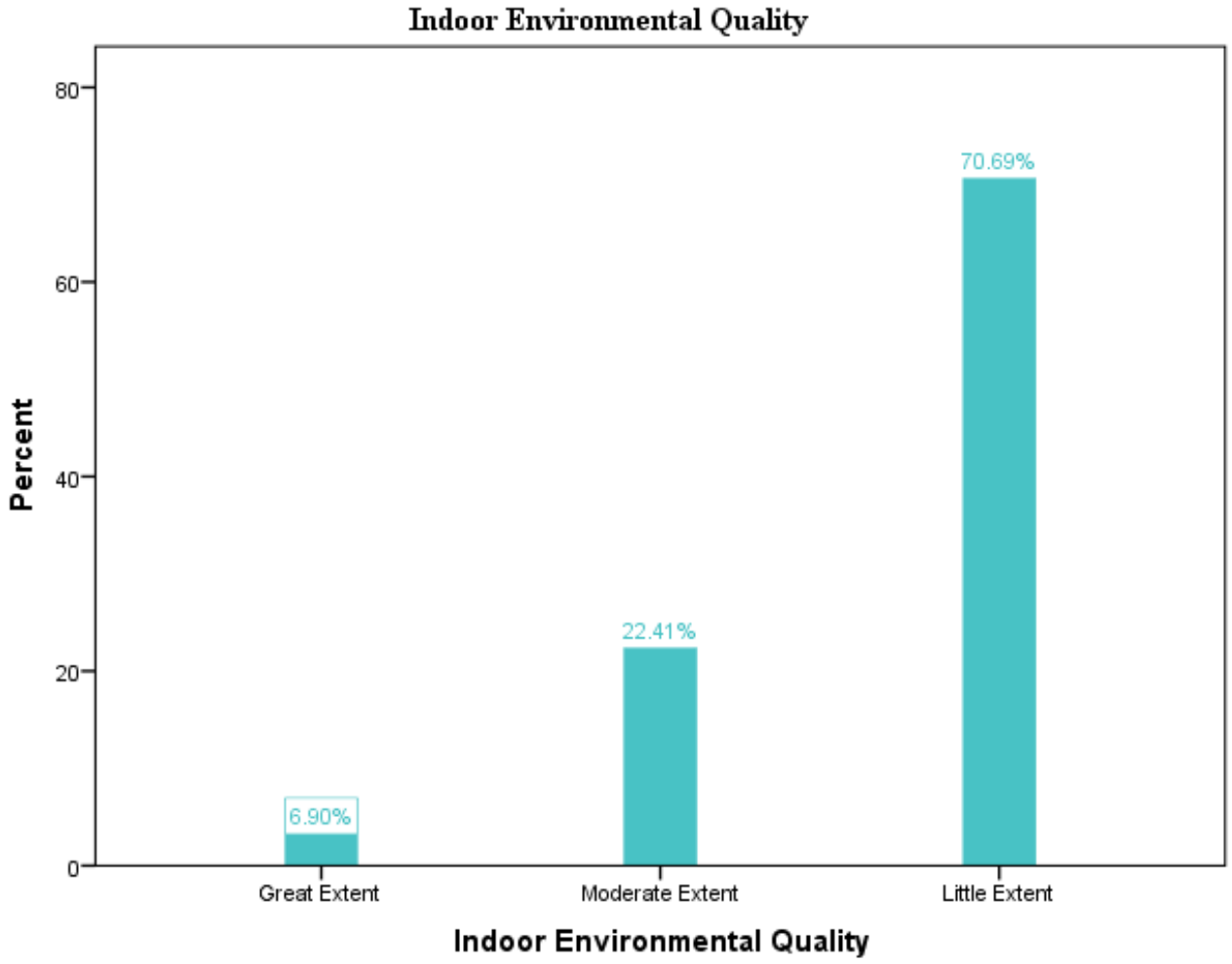
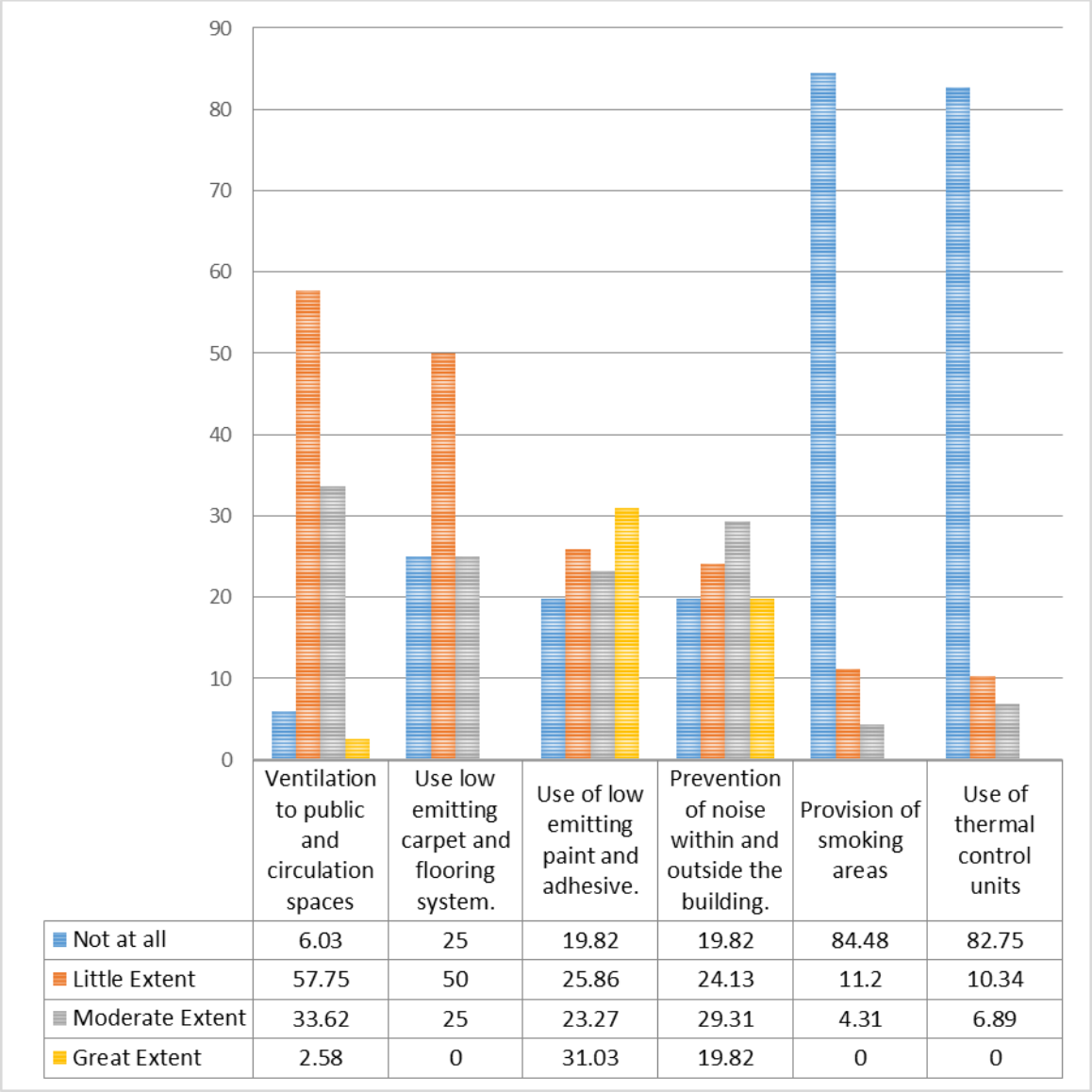


Figure 10: Extent of adoption of Environmental Quality



	Ventilation to public and circulation spaces	Use low emitting carpet and flooring system.	Use of low emitting paint and adhesive.	Prevention of noise within and outside the building.	Provision of smoking areas	Use of thermal control units
Not at all	6.03	25	19.82	19.82	84.48	82.75
Little Extent	57.75	50	25.86	24.13	11.2	10.34
Moderate Extent	33.62	25	23.27	29.31	4.31	6.89
Great Extent	2.58	0	31.03	19.82	0	0

Figure 11: The incorporation of environmental quality in commercial buildings

Source: Author (2018)

4.5 The factors impeding the implementation of green building concepts.

In order to determine the challenges faced by practitioners in adoption of green building concepts, respondents were asked to use a 5-point scale ,with 1 being the lowest grade and 5 being the highest grade. To determine the extent to which the identified challenges in the literature review hinder increased adoption. An analysis was done by combining respondents in grade 3, 4 and 5 where a higher number of respondents meant that the factor posed a high challenge whereas a lower number of respondents were interpreted as a less challenge in adopting the concept.

Figure 12 indicate the responses in frequency for the challenges in the adoption of the concepts.

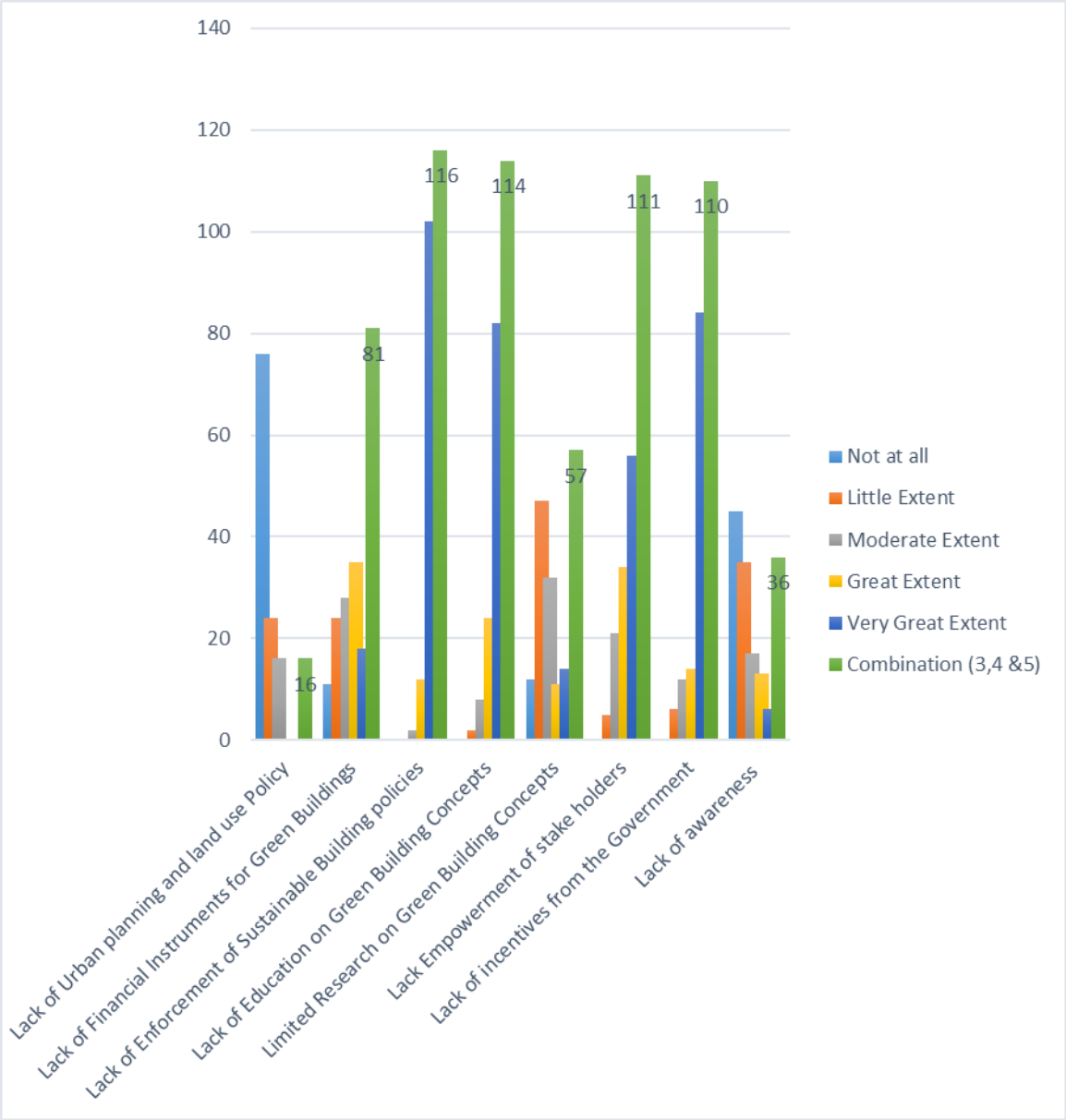


Figure 12: Factors impeding the implementation of green building concepts.

Source: Author (2018)

From the figure above, the following observations and interpretations were made: the respondents strongly agreed that the lack of enforcement of sustainable building policies is a major challenge in the adoption of green building concepts as ranked first. The lack of education on green building concepts was ranked 2nd, the lack of empowerment of stakeholders was

ranked 3rd, the lack of incentives from the government was ranked 4th; the lack of financial instruments for green buildings was ranked as number 5th, the limited research on green building concepts was ranked as number 6th, the lack of awareness was ranked as number 7th and the lack of urban planning and land use policy has least impact in the adoption of green building concepts and ranked number 8th .

The lack of enforcement of sustainable building policies is the biggest challenge in the adoption of green building concepts (102 respondents selected this impact at very great extent), and studies have shown that it is difficult to enforce sustainable building policies as enforcement requires satisfactory education and training of building inspection teams (Anderson, Lyer, & Huang, 2004). They suggested that improved enforcement could be achieved through voluntary schemes and the use of incentives to overcome the challenge.

Findings by Tessema et a (2010) contrasts with these findings and indicate that the biggest challenges facing developed and developing countries in promoting green buildings are inadequate urban planning. The findings by McGraw (2003) on construction smart market differ again with these findings and indicate that the higher cost of green building work is seen as the biggest obstacle between current adoption and future growth. However, the authors also points out that the second most important challenge is the lack of enforcement depending on the region. In this context, Rwanda generally, the lack of enforcement is a leading challenge to adoption because of the inability and inefficiency of the institution in charge of construction activities as noted during interviews.

4.6 The appropriate strategies for implementing green building concepts

The 4th objective of the study was to determine appropriate strategies for implementing green building concepts in commercial building in Rwanda. In relation to this objective, respondents were asked to use a 5 point scale to determine appropriate strategies that can be used to promote uptake of green building concepts.

Figure 13 Responses on the factors promoting uptake of green building concepts.

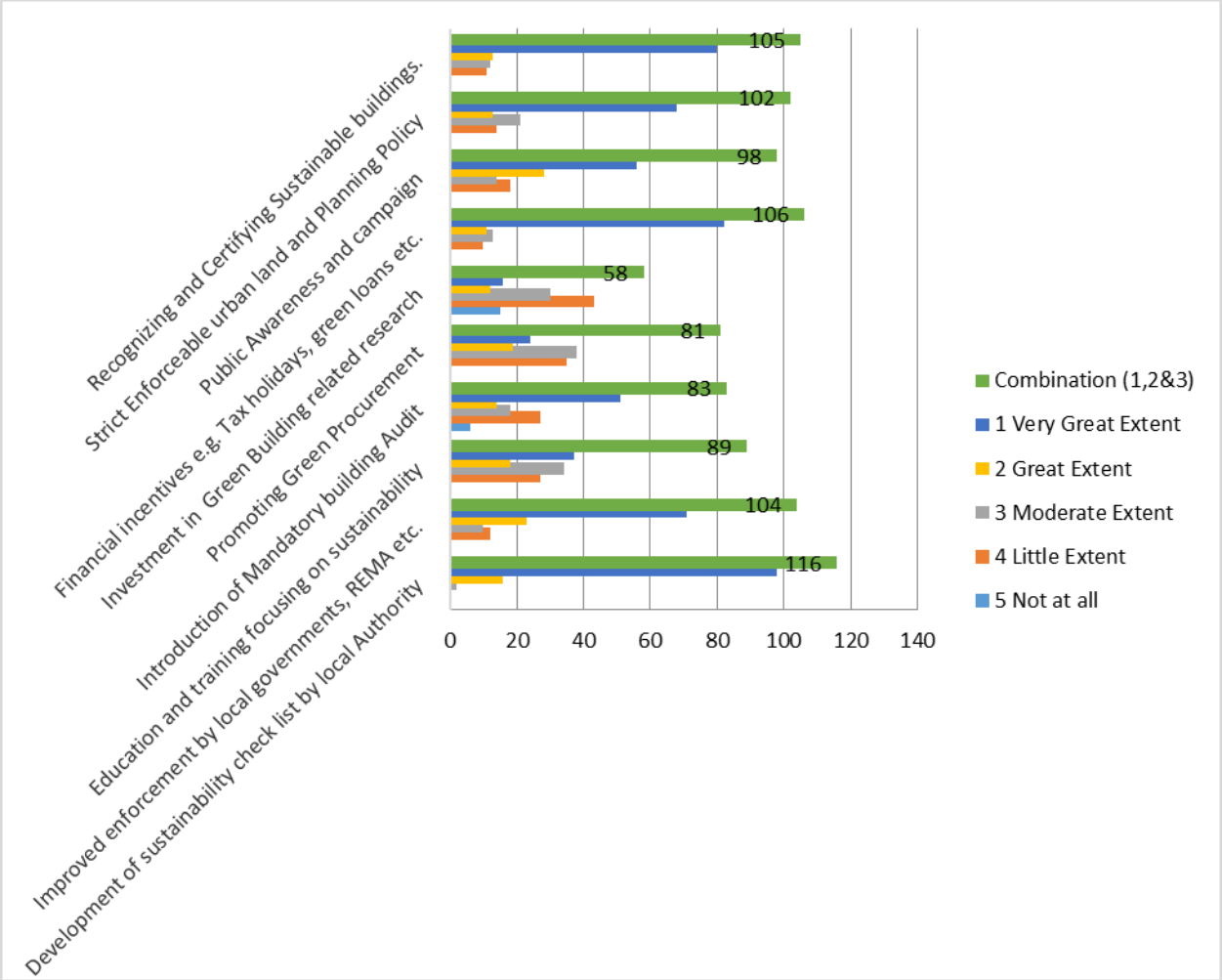


Figure 13: The appropriate strategies for implementing green building concepts.

Source: Author (2018)

The study revealed that development of sustainability checklist by local authority was one of the fastest ways to promote uptake of green building concept as indicated by 116 respondents. This strategy is followed by financial incentives like green loans (all respondents: 106). Other strategies for promoting uptake in order of priority included recognizing and certifying sustainable buildings (105 respondents), improved enforcement by local governments (104 respondents), strict enforceable urban land and planning policy (102 respondents), public awareness and campaign (98 respondents), education and training focusing on sustainability (89 respondents),introduction of mandatory building audit (88 respondents), promoting green procurement (81 respondents), investment in green building related research (58 respondents),

Some of the appropriate strategies that this study suggests in promoting the uptake of green building concepts include, the development of sustainability checklist by one stop centers, provision of financial incentives like green loans with an emphasis on green investments and use

of innovative resource-efficiency practices, enforceable planning policies, improved enforcement of planning bylaws as well as education and training that focuses on sustainability. Strict enforcement of policies particularly at the point of building permit approvals would drive the industry players to embrace green construction in their practices. Education, training and research right from the lower school systems and to institutions of higher learning would produce environmentally focused graduates who will easily embrace sustainability concepts in their projects. The next chapter of the study presents recommendation and conclusions.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 Introduction

A green building ensures many environmental, economic and social benefits to the owners and users of the built environment. With the exalted growth in the construction industry, there is a great need to encourage the adoption of green building concept for construction of buildings in Rwanda. This chapter presents the overall conclusion and recommendations, which are based on the findings of this study.

5.1 Conclusion

Despite the high awareness (90.2% of respondents) about green building concepts among the practitioners, the extent of adoption of the concepts in commercial buildings is only 17.9%. Generally, as shown, these findings are similar to other findings in the developing countries especially in Africa where only South Africa and Egypt have Green Building Councils. It is therefore imperative that more stakeholders adopt more green concepts in the their projects.

The study also revealed that in water and conservation concept, rain water harvesting was the most incorporated concept as 37.1% of respondents had applied the concept at a very great extent, whereas water efficient fixtures was the second most incorporated concept as 15.5% of respondents applied the concept at a great extent. Under energy efficiency concept the use of energy conservation measures was the most adopted concept (48.2% of respondents had adopted the concept at a great extent) followed by the use of day lighting with as 20.7% of respondents adopting the concept also to a great extent whereas the last is the use of building energy management system as 95.7 % of respondents did not consider this concept.

Adherence to local zoning requirements under sustainable site was the most adopted concept (74.13% of respondents had adopted this concept at a very great extent) whereas the use of materials with low environmental impact was most adopted with 44.8% of respondents adopting the concept to a great extent. In environmental quality, the use of low emitting paint and adhesives was the most applied concept with 31% of respondents adopting the concept to a great extent. The study also revealed that water recycling (30.1%), use of other sources of energy e.g. charcoal, gas, diesel, etc. (37.9 %), Management of storm water (84.4%), use of recycled materials (54.3%) and provision of smoking areas (84.4%) were the least adopted concepts in commercial buildings.

The findings demonstrated that there is need to develop guidelines and policies for enforcement of sustainable building concepts, education on green building concepts, empowerment of stakeholders and introduction of incentives from both local and national governments as the lack of these factors were found as important challenges practitioners faced in the adoption of the concepts. Consequently, the strategy would be to develop sustainability checklist by local authority, financial incentives like green loans, recognizing and certifying sustainable buildings as well as improved enforcement by local governments as found out in the adoption strategies.

5.2 Recommendations

Based on the findings of this study, the following recommendations are hereby made with a view of increasing the uptake and adoption of green building concepts in commercial buildings.

Table 7: Recommendations for uptake of green building concepts

Item	Findings	Recommendations
1	The level of awareness of green building concepts by practitioners is high (90.2%)	The practitioners and players in the built environment have to translate awareness into practice through introduction of financial incentives like green loans.
2	The extent of adoption of green building concepts by practitioners is low (17.9%)	- Practitioners need to explore and adopt concepts especially at project design stages and implementation phase. - The government of Rwanda through one stop centers can also start obliging all developers to include some green building concepts in all of their future projects before providing building permits. In this way, clients and architects have no choice but to comply with the requirements.
3	Rain Water Harvesting, adherence to local zoning requirements, energy conservation measures by use of cash powers, use of materials with low environmental impact and Use of low emitting paint and adhesives were popular concepts adopted by practitioners	Players in the built environment should view green building as a system and incorporate the whole concepts together as opposed to adopting single concepts
4	Lack of: - enforcement of sustainable building policies, - education on green building concepts and - incentives from the government	- Ministry of infrastructure (MININFRA) through One - Stop Centers together with Rwanda environmental Management Authority (REMA) should develop guild lines and policies for enforcement of sustainable building concepts and introduction of incentives from both local and national governments. - Education programs should be conducted in the private and government sectors to increase green

	These are the greatest hindrance facing practitioners in the adoption of green building concept	knowledge, concepts and public awareness. The programs that already providing should be widely expanded. In addition, some courses and seminars should be provided to the construction industry players in order to augment their knowledge on specific green strategies, techniques and materials. Furthermore, there should be collaborations with local universities, colleges to establish green building practices in their coursework's / programs.
5	The development of sustainability checklist by local Authority, financial incentives like green loans, recognizing, certifying sustainable buildings and improved enforcement by local government and public awareness and campaign as strategies would promote uptake of green building concepts.	- Follow up on the enforcement of the policies as well as education and training focusing on sustainability. - The government of Rwanda can bring in foreign experts and at the same time, provide training so that we can have our own experts and - The training on awareness and adoption of the environmentally friendly buildings and products must also be sensitive, not only to the primary stakeholders in the construction industry, but also to the public to increase the demand for green buildings. - The private sector should develop a green strategy and do not rely solely on the government. They need to think about and prepare their own financial institutions. For example, financial institutions such as banks can provide more attractive credit for green development investors; provide green incentive programs and tax exemptions for construction companies and participants involved in green development. - Due to the high initial capital cost, green investment is not always the first choice for investors. Incentive programs should be established and financial support provided to local manufacturers. - Many green materials are imported from abroad. Local suppliers and manufacturers should be strengthened through government incentives. In addition, the government should promote and encourage the use of local green materials. Local construction companies, suppliers or manufacturers will

		be more environmentally friendly if supported by the government. Moreover, incentive plans and tax exemptions should be published and made available to the public. In that way, the public knows that such a policy exists.

5.3 Further research

This study suggests further research to be carried out on perception and the knowledge of green buildings in Rwanda. This will help to determine the level of knowledge penetration of professionals and practitioners in the built environment and better understand the benefits and significant features of green buildings. The study also suggests further research on the challenges in implementing green building concept and the research on the direct environmental, social and economic benefits that green buildings can bring to Rwanda, as this will facilitate local manufacturers to include green product lines in their production, which will encourage wider and faster acceptance of green building concepts.

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Appendix 1: Benefits of sustainable design

Table 8: Benefits of sustainable design

Key principles	Economic	Societal	Environmental
Sustainable Sites	• Reduced costs for site preparation, parking lots and roads • Lower energy costs due to optimal orientation • Less landscape maintenance cost	• Improved aesthetics (e.g., better appearance of site to neighbors) • Increased transportation options for employees	• Land preservation • Lower resource use • Protection of ecological resources • Soil and water conservation • Reduced energy use and air pollution
Water Efficiency	• Lower first costs • Reduced annual water costs and wastewater costs	• Preservation of water resources for future generations and for recreational and agricultural uses. • Fewer waste water treatment plants	• Lower potable water use and pollution discharges to waterways • Less strain on aquatic ecosystems in water-scarce areas • Preservation of water resources for wildlife and agriculture
Energy Efficiency	• Lower first costs, when systems can be downsized due to integrated energy solutions • Lower annual fuel and	• Improved thermal conditions; better occupant comfort satisfaction • Fewer new	• Lower electricity and fossil fuel use • Less air pollution and carbon dioxide emissions

	electricity costs due to the reduced peak power demand • Reduced demand for new energy infrastructure, lowering energy costs to consumers	power plants and transmission lines	• Decreased impact of fossil fuel production and distribution
Materials and Resources	• Decreased first costs due to material re-use and use of recycled materials • Lower costs for waste disposal • Decreased replacement cost for more durable materials • Lower costs for new landfills	• Fewer landfills and associated nuisances • Expanded market for environmentally preferable products • Decreased traffic due to use of local/regional materials	• Reduced strain on landfills. Reduced virgin resource use • Healthier forests due to better management • Lower energy use for material transportation • Lower energy and pollution • Increase in local recycling market
Indoor Environmental Quality	• Organizational productivity improvements due to improved worker performance, lower absenteeism, and reduced staff turnover • Lower disability/ health insurance	• Reduced adverse health impacts • Improved occupant satisfaction and comfort. • Better individual productivity	• Better air quality inside the facility, including reduced volatile organic emissions, carbon dioxide and carbon monoxide

	costs. • Reduced threat of litigation		
Commissioning, Operation and Maintenance	• Energy cost reduction • Reduced cost of dealing with complaints of occupant/owner • Longer building and equipment lifetimes	• Improve occupant productivity, satisfaction, health, and safety	• Lower energy consumption, as well as air pollution and carbon dioxide emissions and other environmental impacts of energy production and use

(Source: Ries et al., 2009)

Appendix 2: Letter of introduction

UNIVERSITY OF RWANDA

COLLEGE OF SCIENCE AND TECHNOLOGY

SCHOOL OF ARCHITECTURE AND BUILT ENVIRONMENT

MASTERS OF GEO-INFORMATION, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Dear Sir/Madam,

RE: Permission to Conduct a Study on Assessment of Awareness Level of Green Building Concepts in Kigali Commercial Property Development.

I am a student at University of Rwanda, College of Science and Technology, School of Architecture and Built Environment undertaking a Master's degree **of Geo-Information, Environment and Sustainable Development**. My research thesis is titled, '**Assessment of Awareness level of Green Building Concepts in Kigali commercial property development: A Case study of Kigali City.**

The main objective of the study is to Asses Awareness level of Green Building Concepts among Kigali commercial property developers & stakeholders, its benefits and to determine the challenges faced by developers and practitioners in the adoption of these concepts. All of the responses in the study will be recorded anonymously and with utmost confidentiality and the findings shall be used for academic purposes only. Your participation and cooperation will be highly appreciated.

Thank you

For More Information Contact Marc MINANI 0783773233 email:marcminani03@gmail.com

Appendix 3: Questionnaire for consultants involved in design and implementation.

Dear respondent,

This questionnaire aims to collect information related to **on Assessment of Awareness Level of Green Building Concepts in Kigali Commercial Property Development**. The information given is for academic purpose only and will be treated as very confidential.

Introduction

Green building concepts are based on the principles of resource efficiency, health and productivity. It involves an integrated approach in which a building project and its components are viewed on a full cycle basis. They use **less energy**, **water** and **natural resources** compared to the convectional buildings. They also create less waste and provide healthier living environment, further they incorporate features such as efficient use of water, energy efficient and eco-friendly environment. The buildings use renewable energy and recycled materials, embrace effective use of landscape and have improved indoor quality for health and comfort.

Section A: Information on respondent

1. Profession

Architect ☐ Quantity Surveyor ☐ Project Manager ☐ Property Manager ☐

Engineer – Electrical ☐

Structural / Civil ☐

Mechanical ☐

Others, specify……

2. Professional Experience

a) Below 5 ☐ 6 - 10 ☐ 11 - 15 ☐ 16 - 20 ☐ Over 20 ☐

Section B: Specific Questions 1. Adoption of Green Building Concepts

a) Are you aware of the following green building concepts? Tick **Yes / No.**

	Green Building Concept	**Example**	**Yes**	**No**
1	Water Efficiency	e.g. water conservation measures, water efficient fixtures etc.		
2	Energy Efficiency	e.g. Use of day lighting, use of renewable sources of energy e.g. solar etc.		
3	Use of Sustainable Material	e.g. use of recyclable and low toxic materials e.g Like Bamboo floor, Clay Plaster, Hydraulic Lime Plaster, Lime Paint, Recycled Stone Tile etc.		
4	Use of Sustainable Site Practices	e.g. landscaping , sticking to zoning requirements, etc.		
5	Indoor Environmental Quality	e.g. provision of adequate ventilation, thermal and sound control, etc.		

b) Among the Projects you have completed in the last 5 years, have you incorporated any of the Green Building Concepts?

Yes ☐

No ☐

c) If yes, Green Building Concepts encompass five environmental categories namely Water and Energy efficiency, Sustainable site, Materials and indoor environmental quality. Which concept did you apply in your commercial building project? **Please tick Yes or No.**

	Category	**Yes**	**No**
1	Water Efficiency		
2	Energy Efficiency		
3	Sustainable Materials		
4	Sustainable Site Practices		
5	Indoor Environmental Quality		
6	None		

d) To what extent did you incorporate the **five environmental categories**?

Use a **5 point scale** where **5** Not at all; **4** Little Extent; **3** Moderate Extent; **2** Great Extent and **1** Very Great Extent,

	Category	**5**	**4**	**3**	**2**	**1**
1	Water Efficiency					
2	Energy Efficiency					
3	Sustainable Materials					
4	Sustainable site practices					
5	Indoor Environmental Quality					

e) The table below shows different Green building concepts used in different countries, using a **5 point likert scale,** Rate the extent to which you have applied these concepts .

A	WATER EFFICIENCY AND CONSERVATION	Not at all	Little	Moderate	Great	Very Great
		1	2	3	4	5
a	Rain Water Harvesting					
b	Water recycling					
c	Water efficient Fixtures					
d	Water supply sub meters					
e	Reduced city water for sewage					
f	Water waste reduction					
g	Innovative waste water use					
h	Others Specify……					

B	ENERGY EFFICIENCY	Not at all	Little	Mode rate	Great	Very Great
		1	2	3	4	5
a	Use of renewable energy Sources					
b	Use of Day lighting					
c	Use of Artificial lighting Control					
d	Retrofitting old electrical fittings					
e	Building Energy Management system					
f	Energy Conservation measures					
g	Use of solar.					
h	Others Specify……					
C	CHOICE OF SITE					
		1	2	3	4	5
a	Adherence to Local zoning requirements					
b	Preservation existing vegetation.					
c	Site Landscaping					
d	Management of storm water					
e	Others Specify……					
D	MATERIALS					
		1	2	3	4	5
a	Use of local materials.(No imports)					
b	Use of materials that can be reused or recycled after the building life.					

d	Use of local components					
e	Use of materials with low environmental impact.					
f	Use of Low Toxic material					
E	**PERFORMANCE IN USE & ENVIRONMENTAL QUALITY**					
		1	**2**	**3**	**4**	**5**
a	Ventilation to public and circulation spaces					
b	Use low emitting carpet and flooring system.					
c	Use of low emitting paint and adhesive.					
d	Complaints arising from users					
e	Prevention of noise within and outside the building.					
f	Provision of smoking areas					
g	Use of thermal control units					
F	**WASTE REDUCTION & DISPOSAL**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
a	Provision of Waste management plan					
b	Provision of Maintenance services.					
c	Hazardous waste control and disposal					
d	Provision of different disposal methods					

2. Challenges hindering uptake of Green Building Concepts

a) From the table below please **Rank** in a **scale of 1 – 5** the factors you feel largely affect the adoption of Green Building Concepts in Rwanda, where **1** is the lowest rank and **5** the highest.

	FACTORS HINDERING INCREASED ADOPTION	1	2	3	4	5
1	Lack of Urban planning and land use Policy					
2	Lack of Financial Instruments for Green Buildings					
3	Lack of Enforcement of Sustainable Building policies					
4	Lack of Education on Green Building Concepts					
5	Limited Research on Green Building Concepts					
6	Lack Empowerment of stake holders					
7	Lack of from incentives from the Government					
8	Lack of awareness					
9	Others, …….. ..Specify.					

b) From your experience to what extent do the following challenges hinder increased adoption of Green building concepts in Rwanda. Use a **5 point scale** where **5** Not at all; **4** Little Extent; **3** Moderate Extent; **2** Great Extent and **1** Very Great Extent

	FACTORS HINDERING INCREASED ADOPTION	5	4	3	2	1
1	Lack of Urban planning and land use Policy					
2	Lack of Financial Instruments for Green Buildings					
3	Lack of Enforcement of Sustainable Building policies					
4	Lack of Education on Green Building Concepts					
5	Limited Research on Green Building Concepts					
6	Lack Empowerment of stake holders					
7	Lack of from incentives from the Government					
8	Lack of awareness					
9	Others, ……..Specify					

3. Strategies to increase / promote implementation of Green Building concepts

a) Which of the following strategies do you think would **promote acceptance** of Green Building Concepts in commercial Buildings in Rwanda? Use a **5 point scale** to **Rank** the strategies where **1** is the lowest and **5** the highest Rank

	STRATEGIES FOR UPTAKE OF GBCs	1	2	3	4	5
1	Development of sustainability check list by local Authority					
2	Improved enforcement by local governments, REMA etc.					
3	Education and training focusing on sustainability					
4	Introduction of Mandatory building Audit					
5	Promoting Green Procurement					
6	Investment in Green Building related research					
7	Financial incentives e.g. Tax holidays, green loans etc.					
8	Public Awareness and campaign					
9	Strict Enforceable urban land and Planning Policy					
10	Recognizing and Certifying Sustainable buildings.					
11	Others, ……..Specify					

b) Use a **5 point scale where 5** Not at all; **4** Little Extent; **3** Moderate Extent; **2** Great Extent **1** Very Great Extent. To **what extent** can these strategies promote uptake of Green Building Concepts in Rwanda?

	STRATEGIES FOR UPTAKE OF GBCs	5	4	3	2	1
1	Development of sustainability check list by local Authority					
2	Improved enforcement by local governments, REMA etc.					
3	Education and training focusing on sustainability					
4	Introduction of Mandatory building Audit					
5	Promoting Green Procurement					
6	Investment in Green Building related research					
7	Financial incentives e.g. Tax holidays, green loans etc.					
8	Public Awareness and campaign					
9	Strict Enforceable urban land and Planning Policy					
10	Recognizing and Certifying Sustainable buildings.					

Any other additional information / comment you would like to make on this subject

……
……
……

THANK YOU FOR FILLING THE QUESTIONNAIRE AND YOUR TIME.

Appendix 4: Interview schedule & guide questions

PARTICIPANTS	**NUMBER**	**INTERVIEW FOCUS**
Director Of Kigali City One Stop Center	1	How to promote uptake of Green Building? Concepts and their adoption. Strategies of implementing GBCs.
Director in Charge of Housing and Human Settlement (MININFRA)	1	How to promote uptake of Green Building? Concepts and their adoption. Strategies of implementing GBCs.
The executive secretary of Rwanda Green Building Organization (RwGBO)	1	How to promote uptake of Green Building? Concepts and their adoption. Strategies of implementing GBCs.
Director in charge of facility and estate management (RHA)	1	How to promote uptake of Green Building? Concepts and their adoption. Strategies of implementing GBCs.
Director of environmental and pollution control (REMA)	1	GBCs adopted in commercial buildings. Strategies of implementing GBCs.
President of Institute of Engineers in Rwanda	1	Awareness level of Engineers on adoption of green building concepts. Challenges hindering uptake and implementation of Energy related GBC. Strategies of implementing GBCs.
President of Institute of Rwanda Institute of Architects (RIA)	1	Awareness level of Architects on adoption of green building concepts. How to promote uptake of Green Building? Concepts and their adoption. Strategies of implementing GBCs.

1. What are the challenges hindering uptake of solar Energy?

2. How successful has the retrofitting exercise by your company as a strategy for implementing uptake by your company been?
3. To what extent has urban planning and land Policy improved implementation of Green building concepts?
4. How does Rwanda Environmental Management Authority intend to promote implementation of green construction concepts?

Appendix 5: Inspection check list

1.1 Extent of adoption.

The checklist below will be used to Assess Awareness level of Green Building Concepts in Kigali commercial property development. Some of the green concepts will not be included in the observation checklist since the sample will be drawn from already existing buildings.
The checklist will be divided into five themes namely

- Water efficiency and conservation,
- Energy efficiency,
- Sustainable sites,
- Waste disposal and
- Internal performance of the building.

The themes for the checklist are based on the international rating systems which include LEED, USGBC among others. It is worth noting that not all the aspects of international systems were adopted in this checklist as they are only applicable in those countries.
The researcher after observation will through the questionnaires and interviews confirm the extent to which the green building concepts have been incorporated in the sampled buildings. During observation the researcher will tick and make remarks on the Green Concepts adopted in the sampled commercial buildings within Kigali which were constructed in the last 5 years.

INSPECTION CHECK LIST GBCs ADOPTED IN COMMERCIAL BUILDINGS IN KIGALI CITY

	WATER EFFICIENCY	**YES**	**NO**	**REMARKS**
a	Rain Water Harvesting			
b	Water recycling			
c	Water efficient Fixtures			
d	Water supply sub meters			
e	Reduced city water for sewage			
f	Water waste reduction			
g	Innovative waste water use			
h	Others			
	ENERGY EFFICIENCY			
a	Use of renewable energy Sources			
b	Use of Day lighting			
c	Use of Artificial lighting Control			
d	Retrofitting old electrical fittings			
e	Building Energy Management system			
f	Energy Conservation measures			
g	Use of solar.			
h	Others			
	CHOICE OF SITE			
a	Adherence to Local zoning requirements			
b	Preservation existing vegetation.			
c	Site Landscaping			
d	Management of storm water			
e	Others			
	MATERIALS			
a	Use of local materials.(No imports)			
b	Use of materials that can be reused or recycled after the building life.			
d	Use of local components			
e	Use of materials with low environmental impact.			
f	Use of Low Toxic material			
g	Others			

INSPECTION CHECK LIST

GBCs ADOPTED IN COMMERCIAL BUILDINGS IN KIGALI CITY

	PERFORMANCE IN USE & ENVIRONMENTAL QUALITY	**YES**	**NO**	**REMARKS**
a	Ventilation to public and circulation spaces			
b	Use low emitting carpet and flooring system.			
c	Use of low emitting paint and adhesive.			
d	Complaints arising from users			
e	Prevention of noise within and outside the building.			
f	Provision of smoking areas			
g	Use of thermal control units			
1.15	**WASTE REDUCTION & DISPOSAL**			
a	Provision of Waste management plan			
c	Provision of Maintenance services.			
d	Hazardous waste control and disposal			
e	Provision of different disposal methods			