UNIVERSITY OF NAIROBI

SCHOOL OF THE BUILT ENVIRONMENT

DEPARTMENT OF ARCHITECTURE AND BUILDING SCIENCE

A COMPARISON OF GLOBAL RATING SYSTEMS IN GREEN BUILDING WITH THE SAFARI GREEN BUILDING INDEX.
A CASE OF NAIROBI, KENYA.

BY

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SEPTEMBER 2018

DECLARATION

....

This is my original work and to the best of my knowledge has not been presented for a degree in any other institution

Author: Ochieng Kevin Oduor

Signature.. Date...

This project report is submitted in partial fulfilment of the examination requirements for the award of the Master of Architecture Degree, Department of Architecture and Building Science, University of Nairobi

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Signature.......................................Date................................

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Signature.. Date...

DEDICATION

I wish to dedicate this research study to the glory of the Almighty God. I also dedicate this to my wife and daughter. Thank you for the support through this process.

ACKNOWLEDGEMENTS

I am eternally grateful to Arch. Musau Kimeu for his guidance and stewardship. Arch. Bob Njoroge for his assistance and always pointing me to the right direction. I would like to thank the Kenya green building council for providing me with all the necessary information and sitting through the lengthy interviews. I am also very grateful to all my classmates who helped me question my understanding of environmental design.

ABSTRACT

The effect of building design and construction on the planet's natural environment has in the past two decades come to the forefront of the global conservationist agenda. The use of raw materials as well as the production of waste materials during building construction, renovation, repurposing and occupancy all have a lasting effect on the immediate and surrounding area where the building is situated. To determine the extent of this impact, several environmental sustainable assessment programs are continuously developed worldwide to identify the environmental and energy effect of buildings. With the increased realization of the harm that building construction can cause to the natural environment, came the creation of green building technology, rating systems and standards that aim to mitigate these potential negative effects before they occur through sustainable design.

This study focused on four such building rating systems that are used in Kenya to assess green buildings in Nairobi. The rating systems examined in this study are the Safari Green Building Index (SGBI) rating system developed in Kenya, the Building Research Establishment Environmental Assessment Method (BREEAM) developed in the UK, the Green Star rating system developed in Australia and, the Leadership in Energy and Environmental Design (LEED) system developed in the USA. The overriding objective of this study was to determine whether internationally developed rating systems are better suited to evaluate green buildings in Nairobi County than locally developed ones.

To this end, the study examined the three green building rating systems (Green Star, BREEAM and LEED) used internationally to discern the similarities and differences among them as regards to their development, implementation, and evaluation criteria. The study also examined the

Safari Green Building Index with the intent of determining its suitability for use in Nairobi taking into consideration the unique climatic and socio-economic conditions in Kenya.

The study critically analyzed three green buildings located in Nairobi County using the Green Star SA- Kenya green building rating system and the Safari Green Building Index to identify the points of divergence between these two green building rating systems. The buildings analyzed in this study were the Garden City Residential Buildings – Phase 1, The University of Nairobi Towers and the Strathmore Business School building in Strathmore University. The study found that while the Green Star rating system comprehensively evaluates internationally accepted green building standards, the Safari Green Building Index is better suited to address the specific building design and construction requirements of green buildings in Nairobi.

The study thus proposes that the Safari Green Building Index or other locally developed rating systems be adopted for use in Kenya and the East African region as a whole. The study also recommends that further research is needed to reassess the environmental impact of green buildings in Nairobi that are certified under international green building rating systems to determine if they are in fact environmentally friendly given the country's unique climatic and socio-economic conditions as well as its present and future environmental conservation objectives.

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ABBREVIATIONS AND ACRONYMS

BRE – The United Kingdom's Building Research Establishment

BREEAM - Building Research Establishment Environmental Assessment

CBD – Central Business District

CASBEE - Comprehensive Assessment System for Built Environment Efficiency

GBCA - Green Building Council of Australia

GRIHA - Indian Green Rating for Integrated Habitat Assessment

GBR – Green Building Rating

G-SEED - Green Standard for Energy and Environment Design

LEED - Leadership in Energy and Environmental Design

SBS – Strathmore Business School

SGBI – Safari Green Building Index

UON – The University of Nairobi

USA - United States of America

USGBC - U.S Green Building Council

DEFINITION OF KEY TERMS

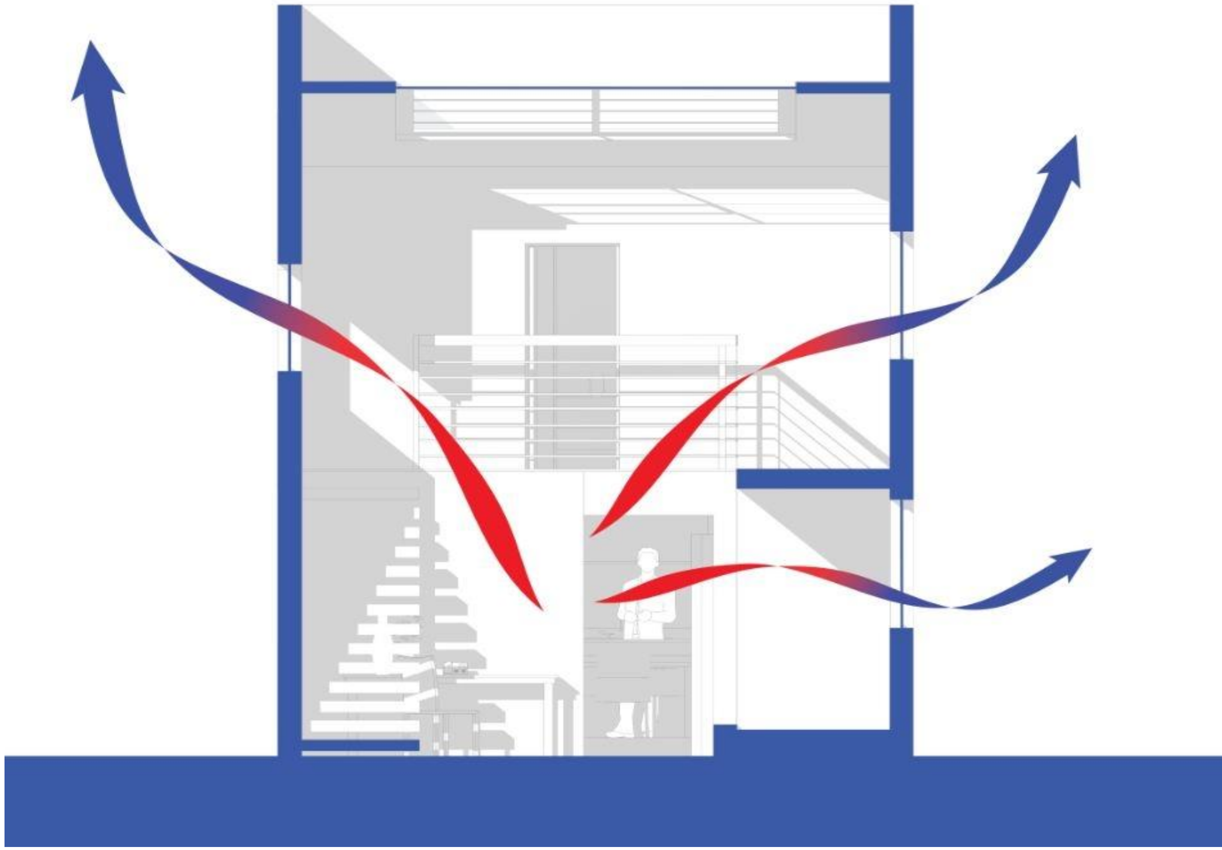
Green – Includes all innovations, designs, technologies, strategies, concepts and building construction products that make effective and efficient use of resources and are environmentally friendly (Hoffman AJ, 2008)

Green Building – Refers to all the design and construction techniques, concepts and processes employed throughout a building's life span that are environmentally conscious and make efficient use of resources (Gottfried, 1996).

Nairobi – Nairobi is the capital city of Kenya covering an area of approximately 696.1 km^2. In this dissertation the name Nairobi refers to the whole County.

System –This refers to a single unit made up of smaller connected parts or subunits symbiotically interrelated with each individual part operating as a system functioning at a lower or sub-level to the main organization or organism thus creating a hierarchy (Oxford, 2014).

CHAPTER ONE: INTRODUCTION



CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Globally, built structures have exerted a significant effect on the quality of the world's micro and macro-climate (Park *et al.,* 2017). This is particularly in terms of general pollution and other environmental costs which come up as a result of their construction, operation and maintenance (Fowler and Rauch, 2006). The areas occupied by these buildings affect the people who live, play and work in them both physically and psychologically (Gang and Li, 2012). Building structures are the main spaces where people conduct majority of their activities and they ought to be carefully constructed to ensure that they create a comfortable and efficient working environment (Pandey, 2015). Environmentally sustainable, efficient and effective initiatives which emphasize on energy and water conservation and waste minimization have emerged all over the world. Pursuant to these ideals, there have been worldwide reductions in carbon emissions and wastage of water and energy (Reed *et al.,* 2011).

Several global sustainable building rating tools such as LEED, the Australian Green Star and BREEAM have been developed in various parts of the world to assist in certifying and rating the performance of buildings depending on their environmental friendliness (Meiring, 2014a). These rating tools were developed by specific countries working independently and using different methodologies, to quantify various building efficiencies (Etto and Ambiente, 2013).

When evaluating existing buildings in terms of their sustainability, rating tools usually adopt either of two distinct approaches - they are the performance based approach or the design based approach. These approaches set the perspective from which green building rating tools certify and rate efficiencies, effectiveness and environmental sustainability of buildings structures (Akadiri et al., 2012). Out of the two, design based approaches are preferred because they certify buildings that seem to be efficient when viewed from the perspective of the design documentation that they utilize. They are mainly used when analyzing new buildings or buildings undergoing extensive renovations (Feltes, 2007). When handling existing buildings, performance based tools are the best because they focus on comparing matrixes such as measured energy consumption and productive outputs and facilities (Etto and Ambiente, 2013).

These two approaches for rating and certifying buildings have their main focus on the effect a building has on its surrounding environment and how efficiently a building's processes for consumption of natural resources or disposal of waste are configured (Say *et al.*, 2008). Majority of the tools in use today tend to address economic and environmental concerns. Some of them also include an additional ecological consideration factoring the inherent costs of building construction and the high consumption levels of natural resources and raw materials during their construction, operation and maintenance (Ehsan *et al.*, 2013).

To address the shortfalls and challenges faced when utilizing the global sustainable building rating systems in Nairobi and to reduce the overreliance on global sustainable building rating systems like LEED and BREEAM (which were originally developed for implementation in other regions with different social economic and environmental conditions), a local green building rating (GBR) system known as the Safari Green Building Index (SGBI) has been developed for adoption in Nairobi and the entire East African region. Since its inception, there has been no academic attempt at comparing its suitability for Nairobi CBD and the East African region vis-a-vis other global rating systems employed locally such as the Australian Green Star, BREEAM and LEED rating systems. This study is therefore designed to compare this new rating system with the more established rating systems and consequently confirm its suitability for this region.

1.2 Problem Statement

Concerted global effort geared towards environmental protection have resulted to the establishment of the global sustainable building rating systems (Sinha and gupta, 2013). GBR systems have had unparalleled success in the provision of a quantifiable metric to measure the contribution of professionals such as architects and engineers towards achieving lasting sustainable development (Reed *et al.*, 2011). All over the world there are many GBR systems in place. They include; the Australian Green Star rating system (Green Star), Leadership in Energy and Environmental Design (LEED) in USA and the UK's Building Research Establishment Environmental Assessment Method (BREEAM) (Reed *et al.*, 2011). However, each of these GBR systems have their own drawbacks and challenges (Sinha and gupta, 2013).

In Kenya and the entire East African region, new construction projects have been relying on global sustainable building rating systems like LEED, Green Star and BREEAM for certification yet these systems were originally developed for other regions with different social economic and environmental conditions (Franzsen, 2002). Further, the organizations that adopt these three international green building rating systems to evaluate buildings constructed locally or regionally do not take into consideration the fact that different countries all over the world have different building codes and further that these building codes exert an influence on the nature of the green building rating tools developed in the different territories or regions. Consequently, the developers of these international GBR systems do so on a general assumption that all other countries using their building rating system are doing so starting from a common environmental standpoint- which is not true as each region has a unique set of environmental characteristics (Akadiri *et al.*, 2012). Also, the energy modeling tool in these global GBR tools are too complicated to be efficiently used in Kenya and the East Africa region (Bernardi and Carlucci, 2017).

In order to address these challenges and effectively rate green buildings on their performance in relation to the environment in Kenya and the entire East Africa region, a local GBR tool known as the Safari Green Building Index (SGBI) was developed in 2012. Being a relatively new system in the market, it is yet to be put to an objective comparative analysis with the more established green building rating systems and consequently confirm its suitability for this region. This study is therefore designed to provide a comprehensive comparison between the three main global building rating systems namely LEED, the Australian Green Star and BREEAM with Safari Green Building Index rating system used in the East Africa region.

1.3 Research Objectives

1. To examine the features of the LEED, Australian Green Star and BREEAM international systems to establish their suitability to rate green buildings in Nairobi.
2. To examine the features of the Safari Green Building Index (SGBI) that was developed for adoption in the East Africa region.
3. To determine whether the Safari Green Building Index is better suited to rate sustainable buildings in Nairobi than international green building rating systems.

1.4 Research Questions

1. What green building aspects are evaluated by the Green Star, LEED and BREEAM rating systems?
2. What are the differences between the Green Star, LEED and BREEAM rating systems?
3. What are the features of the Safari Green Building Index system?
4. Is the Safari Green Building Index better suited to rate green buildings in Nairobi County than international green building rating systems?

1.5 Justification and Significance of the Study

Effective utilization and preservation of natural resources has become a primary concern of present and future human activity and an integral concept of sustainable development especially as relates to enhanced and sustainable environmental, social and economic development. Generally, buildings consume 17% of the fresh water on the earth's surface, 25% of the world's timber produce and 67% of its available materials and energy resources (United Nations / UNESCO, 2014). With a combination of cutting edge technology and innovative architectural design, green buildings serve to enhance human wellbeing and reduce the environmental impact of construction works by creating efficient systems and processes for raw material utilization, waste disposal and reducing harmful emissions (Samer, 2016). It is therefore important that the architectural and construction industries adopts the best green building rating tools which would help them implement green building concepts for specific regions; consequently safeguarding the worlds' limited resources and ensuring social, economic and environmental sustainability.

The findings of this study are useful in the creation of a systematic and valuable reference point which is helpful for architects, developers, landlords, engineers and managers in having a better insight into sustainable rating tools. The development of a suitable and effective GBR system is important for making buildings environmentally sustainable and good for human occupancy in the counties and the country as a whole.

Further, the outcomes of this study serve to provide critical information to decision makers in the construction sector when formulating policies, strategies and development programmes to govern building design, construction and management in the study area and other areas ready to adopt green building technology. The study contributes to the existing knowledge base as regards the application of GBR tools and systems used in the East Africa region and specifically in Nairobi. Further, this research study intends to increase the developers' awareness on the green building technology and the advantages of adopting this technology.

1.6 Study's Scope and Limitations

The study is constrained to Nairobi County which is the capital of Kenya neighboring Kiambu , Kajiado and Machakos Counties. Nairobi County has the largest population in Kenya with over 3 million inhabitants and serves as the political, social, economical and development hub of the country. This study area was selected by the researcher because it is a suitable representative of a cosmopolitan area in the East African region with a proper mix of buildings marked 'Green' and those that are not; all within easy reach of his work station.

Figure 1: Nairobi County Map showing study area.

Source: Google Earth, 2018

The respondents selected to participate in the research included public officials from the Ministries of Lands and Housing, architects of the different green buildings selected, county officials from the County Government of Nairobi, engineers of the selected green buildings, tenants occupying various green buildings and the owners/ managers of the different green buildings. The study is limited to the comparison of one established global rating systems as compared to the Safari Green Building Rating system designed for the East Africa region and more particularly as it has been adopted for Nairobi, Kenya. It is assumed that although all the GBR systems can be used to analyze buildings in Nairobi, depending on various factors such as climate and technology, there is one rating system which is best suited for the region. Therefore this study, aims at identifying the best rating system for buildings in Nairobi in order to enhance sustainability of buildings within the County and the region as a whole.

The study was faced by various limitations and the major ones were;

- The expansive nature of the study area. Nairobi County covers an area of 696.1 Km^2, therefore the green buildings selected were far apart, and hence this inconvenienced the researcher in terms of accessing them. The researcher overcame this challenge by using motorized means of transport including motorcycles.
- Unwillingness of the respondents to make disclosure of vital information. Since property (buildings) ownership and adherence to construction guidelines are very sensitive issues in the study area and Kenya as a whole, various respondents, that is, architects, engineers, property owners in the area, county government officers and officers from the ministry of lands and housing were unwilling to divulge some information pertinent to the study with the researcher despite his assurances of strict confidentiality through the interview process. This inevitably led to the formation of data gaps in the study some of which were remedied by use of information gained from secondary data sources. .
- Financial constraints. A lack of sufficient funding deterred the researcher from visiting a greater number of green buildings in the study area which would help in making a more accurate comparison of the various global green building systems to the Safari Green Building rating index. The researcher mitigated this by conducting a thorough analysis of the few case studies he was able to visit and the available literature when making the comparisons.

1.7 Theoretical Framework

The green building movement was initiated to counteract the adverse effects that buildings exert on the natural environment. International or regional GBR systems were developed to regulate, evaluate and facilitate design innovation within the construction and real estate sectors. As the body of research on the impact buildings on the natural environment continues to grow, these green building rating systems have become increasingly complex and specific in their application. The comparison of the four GBR systems researched in this study (Australian Green Star, LEED, SGBI and BREEAM rating systems) may be conceptualized using the following theories:

1.7.1 Adoption and Diffusion Theory

The adoption and diffusion theory is often used when analyzing the up-take of new innovations within a specific population and has a working model known as the innovation decision model. The model based on the idea that the implementation of a novel concept, process, strategy or technology isn't an independent act but a process that occurs progressively through five stages (Rogers, 1995). Firstly, the innovation has to pass the knowledge stage whereby the innovation's target population discover the new innovation and gain a rudimentary comprehension of what it entails and how it functions. Thereafter the innovation ascends to the persuasion stage whereby the potential adopters form an opinion about the innovation, whether positive or negative. In stage three the innovation is either adopted or rejected by the target population. Stages four and five involve the implementation and confirmation of the innovation (Rogers, 1995). Green building ideas and strategies are in essence innovations in building design and construction and this theory is useful for purposes of making a comparison of different green building rating tool and their adoption in different areas.

1.7.2 Convention Theory

The convention theory's purpose is to explain how market and non-market entities are interrelated. It's based on the idea that people's actions are governed by a common body of rules and that while market forces are one of them, they are others (Loza and Valceschini, 1994). This theory is relevant to this study because green buildings as examples of market commodities rely on multiple quality assurances in their construction and conveyance processes. This degree of quality assurance offered by a green building is determined by considering multiple interrelated factors such as occupant comfort, efficient use of natural resources, minimization of construction costs and so forth.

1.7.3 Sustainability Theory

Sustainability theories endeavor to rank and integrate social and cultural strategies to address environmental concerns. For example economic models look to ensure effective utilization of monetary resources, natural and financial capital resources; ecological models look to protecting a region's natural resources while political models look to protecting human rights and freedoms. Sustainability in this regard encompasses all actions geared towards ensuring the continual usage of some resource for extended future periods (Brown, 2004). Applying the sustainability theory to the comparison of different green building rating tools requires an examination into their suitability for different environments. Since sustainability is an integral element of the green building movement, this theory is useful when determining the environmental impact of building design, construction, renovation and/or demolition.

1.7.4 The General System Theory

General system theory suggests that a system can be viewed as a singular unit composed of several interrelated subunits or parts. Further each subunit or part of the system is itself a complete system and the relation between the subunits and the main system functions as a hierarchy (Mbiti and Blismas, 2009). In the present day this theory is often used when resolving intricate organizational conundrums often with surprising results. The general system theory explains a system's behavior by looking to its inherent feedback control mechanisms, but this does mean that the effects of external factors are ignored. The hierarchal nature of the relations between subunits or subsystems can be designed in such a way as to buffer the larger or general system from adverse external factors (Mbiti and Blismas, 2009).

The general system theory has been used in this study to facilitate the making of a comparison of the four GBR systems and tools and identifies challenges industry professionals may face when adopting them in different environments. This is because green buildings as a product of building processes are created after the incorporation of various inputs in the process from design; construction, use and disposal. The interplay between these independent factors therefore forms the basis of the green building a system.

1.8 Structure of the Study Report

This research is structured into five consecutive chapters preceded by preliminary pages that include the cover page, researcher's acknowledgements and dedication, the table of contents, and the lists of figures and tables.

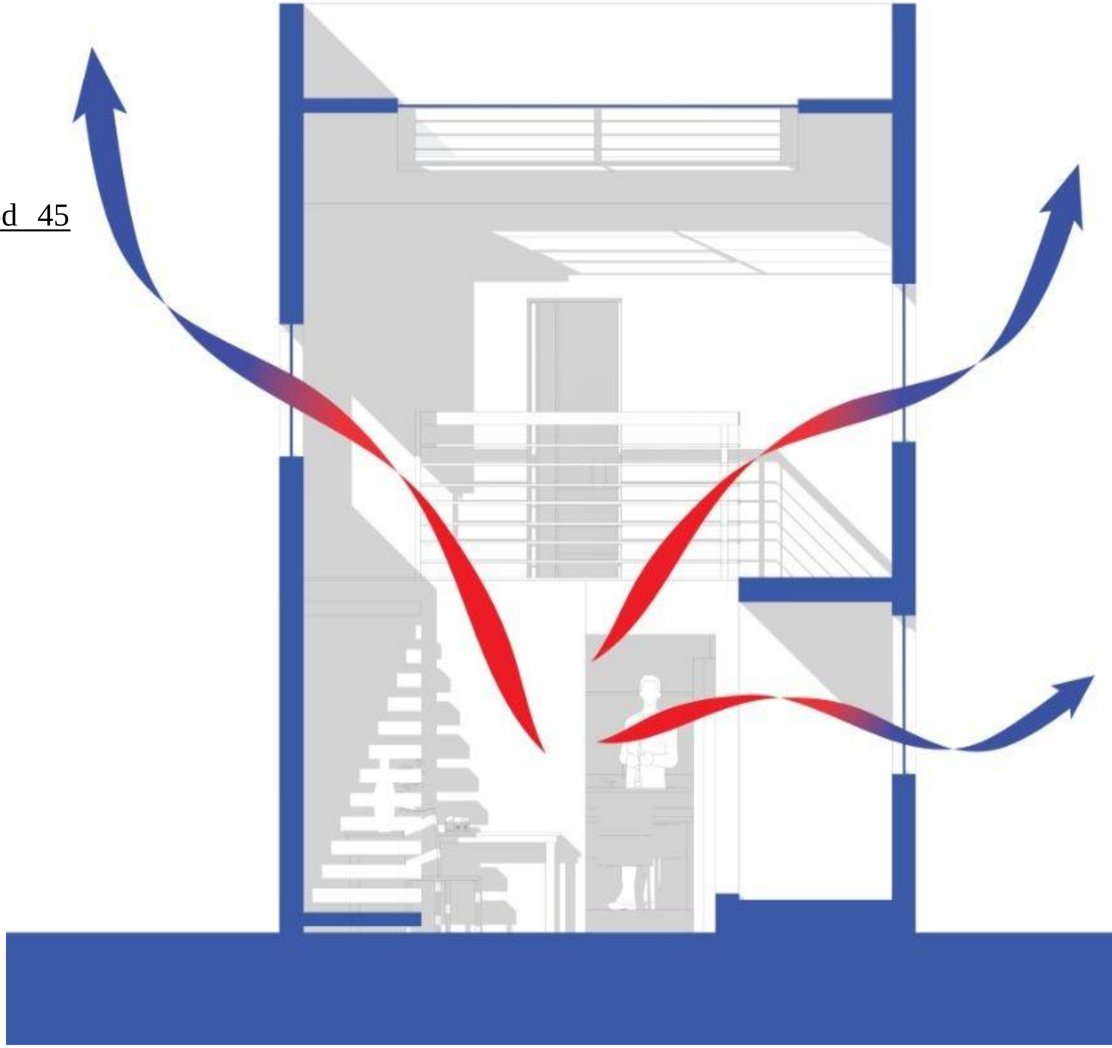
Chapter one contains the introduction to the study, background of the study, statement of the problem, aim and objectives of the study and their corresponding research questions, justification of the study, scope and limitations of the study and the structure of the study.

Chapter two incorporates a review of literature related to GBR concepts and systems currently in use in Kenya. It includes a brief overview of Nairobi County and an in-depth analysis of four green building rating systems – Australian Green Star, BREEAM, LEED and SGBI rating systems.

Chapter three discusses the methodology used to carry out the study and data collection. It includes an introduction to the study, study design and a description of the study area. It also includes the type of data collected during the study, the data collection methods utilized in the study, the sample characteristics and the data presentation and analysis.

The fourth chapter comprises of the data analysis, presentation and discussion while the fifth one contains the conclusions and recommendations of the study as well as opportunities for additional research.

CHAPTER TWO: LITERATURE REVIEW



CHAPTER TWO: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

2.1.1 Green Building Technology

Green building technology can be defined as the careful integration of design strategies that make maximum efficient use of natural resources s, recycle construction waste produced, minimize pollution or environmental degradation and enhance the building's comfort levels for its occupants (Karmany, 2016). The increasing usage of green building rating systems as a way of promoting sustainable building practices has come about due to a change in global aspirations towards countering the adverse effects of built spaces on economic, environmental, economic systems (Ehsan *et al.*, 2013).

2.1.2 Components of Green building design

Green building design involves the use of construction processes and strategies that make the most efficient use of available resources, that do not threaten the health of a building's occupants(and the society at large) and that is conscious to protect the environment around it (Miriam, 1999). Components of green building design are developed from the best practices in sustainable building as relates to sustainable site selection, integrated building design, use of innovation, sustainable waste management and the efficient use of available resources.

These components function to maximize the health, comfort and efficiency of buildings, while at the same time minimizing the environmental and resource use associated with the construction, renovation, occupancy and demolition of buildings. As the body of research into the effects of buildings on the natural environment grows, so does the number of green building concepts or components. Each green building rating system is based on a particular set of green building components to be evaluated. Green building rating systems are often organized into specific categories which contain multiple components.

Some of the components of green building design discussed in this study are listed in the stable below:

Component of Green Building Design.	**Desired outcome.**
Sustainable site selection	The reduction of environmental pollution from construction activity.
Energy efficiency	The reduction of energy consumption in buildings, use of renewable sources of energy.
Water efficiency	The limitation of the use of portable water, recycling of grey water and the use of innovation to reduce water wastage.
Materials and resources	The use of local, recycled or recyclable materials and the diversion of waste materials from landfills.
Acoustic Comfort	Reduce noise pollution, control ambient sound levels.
Sun Control	Ensured optimum thermal mass, maximum use of daylight, minimize reliance on artificial lighting and heating mechanisms, control sun glare.
Indoor air quality	Protection from exposure to noxious gases, hazardous airborne substances, chemical agents or biological processes.
Innovation	Design and implementation of components that exceed minimum green building rating requirements/ standards.
Land ecology	Elimination of unsustainable building practices that degrade the land through loss of biodiversity, desertification or deforestation.
Waste management	Safe disposal of solid waste, proper disposal of post-construction waste, recycling of waste where possible.

Table 1: Components of green building design.
Source: Author

2.1.3 Green building rating systems

In response to the growing trend that embraces green building technology, hundreds of GBR systems have been injected into industry to give procedural guidelines on how to achieve sustainability in the built environment (Bernardi and Carlucci, 2017). All these rating systems are suited to specific regions or countries in the world and they tend to be unique in nature. They provide a method of indicating that a built structure has successfully met a certain level of performance in a singular or cluster of defined criteria (Sinha and gupta, 2013).

Key among the international GBR systems is; the U.S. Leadership in Energy and Environmental Design (LEED) system, the United Kingdom's Building Research Establishment Environmental Assessment Method (BREEAM), the Australian Green Star, the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) from Japan, the Korean Green Standard for Energy and Environment Design (G-SEED) and the Indian Green Rating for Integrated Habitat Assessment (GRIHA) (Reed *et al.*, 2009). However among all these green building rating systems only a few are widely acknowledged and really set a recognizable international standard for sustainable development.

2.2 Green building in Nairobi.

Kenya is experiencing a steady growth in the provision of green buildings. According to the Green Africa Foundation, Kenya comes second only to South Africa in the list of countries in sub- Saharan Africa that have adopted green building standards (Green Africa Foundation, 2018). The bulk of the country's green buildings are located in Nairobi.

2.2.1 The special stature of Nairobi County.

Nairobi City County is one of the 47 counties in the Republic of Kenya. Nairobi City is the administrative capital city of Kenya, Kenya's commercial hub, a centre of industry, education and culture located in the South-Eastern end of the country. It is also the largest city in Kenya. The city and is governed by the County Government of Nairobi headed by a county governor. Nairobi covers a total area of 696.1km^2 and it is located between longitudes 36^0 45' East and latitudes 1^0 18' South with an altitude varying from 1600m to 1800m above sea level. Nairobi is believed to be the most populous city in East Africa, with an estimated population of about 3 million (2009 Census) and it is projected to have a population of 5.2 million by 2021.

This section of the study contains a brief overview of Nairobi's topography, its climatic conditions and the evolution of its post independence architecture. It is intended to bring about a greater understanding of the dynamic nature of Nairobi's environment and its built environment. From this perspective, it will be easier to comprehend the need for green building standards to guide building design and construction in Nairobi as well as the challenges that stakeholders face when adopting internationally and locally developed GBR systems.

2.2.2 Climate of Nairobi.

Nairobi lies on the tropics; between two parallel latitude lines on the surface of the globe i.e latitude 23°27' north to 23°27' south. These are the highest north and south points where the sun is perpendicular at noon at least one day each year. Between these latitudes, the sun is almost directly overhead for most of the year. The tropic north of the equator is called the Tropic of Cancer and the Tropic of Capricorn is to the south of the equator. The temperatures in these areas do not go below 20^0c and most buildings in the area offer relief from the heat. The sun is directly overhead the Tropic of Cancer on 22nd June and the Tropic of Capricorn on 23rd December.

Nairobi is situated in an area that is influenced by monsoonal systems of Asia and the Indian Ocean in Kenya. Its climate is controlled by large scale pressure systems from the Western side of the Indian Ocean. Nairobi's weather is affected by the day to day variation in details of these pressure systems (Morgan 1967).

Its climate can be divided into four seasons;

1. North East Monsoon season
2. The rainy season of late March to May
3. South East Monsoon season
4. Rainy season of November

The table below illustrates Nairobi's Climate.

SEASON	APPROX DURATION	MAIN CHARACTERISTCS
North East monsoon	December to March	North Easterly winds, sunny, warm or hot days, good visibility with occasional showers in December and January.
Rainy season	Late March to May	Light winds which vary in directionality; sometimes they are light Easterly, at other times they are North Easterly. When the winds blow from a South Easterly direction they bring with them periods of rain and showers interspersed with dry periods. The season is generally warm but it becomes cloudier towards the end of the period.
South East monsoon	June to October	South Easterly winds, the days are mainly cloudy or overcast, cool and cold in higher altitudes where mist, fog and drizzle are frequent. The rainfall is sparse at first but it increases gradually with time.
The rainy season	November	The winds are light Easterly, changing from south Easterly to North Easterly throughout the month. The period is usually warm, sunny with frequent rainfall.

Table 2: A summary of the seasons in Nairobi
Source: Adapted from Morgan, 1967

Nairobi enjoys a moderate climate. The city is warm during the months of December and March with average temperatures of 22 degrees Celsius and relatively cold with temperatures dropping to as low as 10 degrees Celsius during the months of June and July.

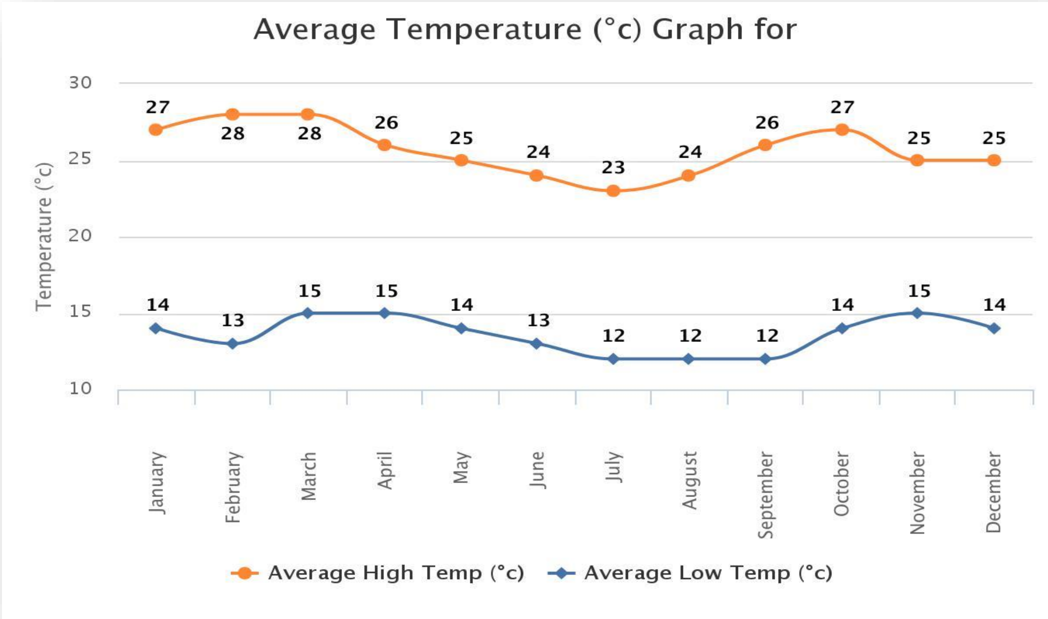


Figure 2: Average Temperature in (°C) for Nairobi County.
Source: World Weather Online, 2018

The average annual rainfall in Nairobi is about 900m. As shown in the graph above, the city has two rainy seasons; the first season (also referred to as the long rains) occurs between the months of March and May and the second season (or short rains) between October and December.

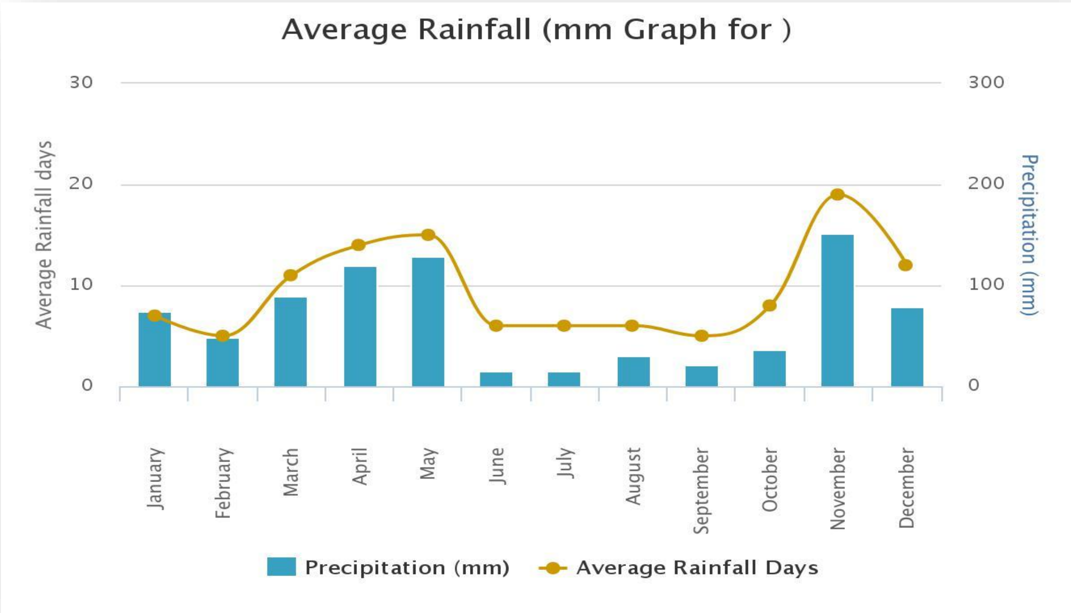


Figure 3: Average Rainfall in (mm) for Nairobi County.
Source: World Weather Online, 2018

Nairobi's tropical climate is advantageous for green building professionals because it affords them the opportunity to construct buildings that make maximum use of the warm temperatures and high sunlight exposure. Green building architects can easily ensure that the buildings that they design in Nairobi consume less energy for heating, cooling and lighting purposes which is not only cost effective, but also environmentally friendly.

2.2.3 The Evolution of Nairobi's Architecture

The development of Nairobi's built environment over time has been greatly influenced by its colonial history and the rich cultural, religious, political, artistic characteristics of its inhabitants. Of these influencing factors, the most predominant is Nairobi's colonial history that is clearly evidenced in the city's architectural vocabulary as expressed in majority of the buildings located in the city's central building district.

Majority of the historic buildings (built between1910-1960) in the city's CBD were constructed based on imported architectural aspirations, standards and values which were then modified slightly to suit the local culture, climate conditions, local traditions and available materials and technology. These historic buildings were mainly designed as per European architectural styles such as the classical revival style, the renaissance revival style, Georgian architectural style and so forth. They were also constructed mainly using locally available materials such as blue granite stone, clay stone and locally harvested sand. Doors and windows were framed from hardwood timber obtained from indigenous trees and grills and other metallic motifs were curved from wrought iron.

Climate responsive building design became more significant during the late 1960's and 1970's. Buildings within the Nairobi's CBD were designed to include sun braking devices that would protect their occupants from direct solar radiation. The ICEA office block on Kenyatta Avenue in Nairobi's CBD reflects this architectural design as a response to climatic concerns. The non-orthogonal and orientation form of this building attempts to respond to the movement of the sun through its lift core that provides shading to a glazed façade.

From the early 1990's to date, the architectural styles Nairobi have become heavily reliant on the use of glass. There has been a sharp spike in the utilization of glass as curtain walling on most facades and more so in windowpanes. The construction of contemporary structures require advanced technological know-how, cement, smooth finishing materials and specially fabricated metals and glass. Since Kenya does not produce most of these building materials, their import content is high requiring ever increasing capital investment to acquire.

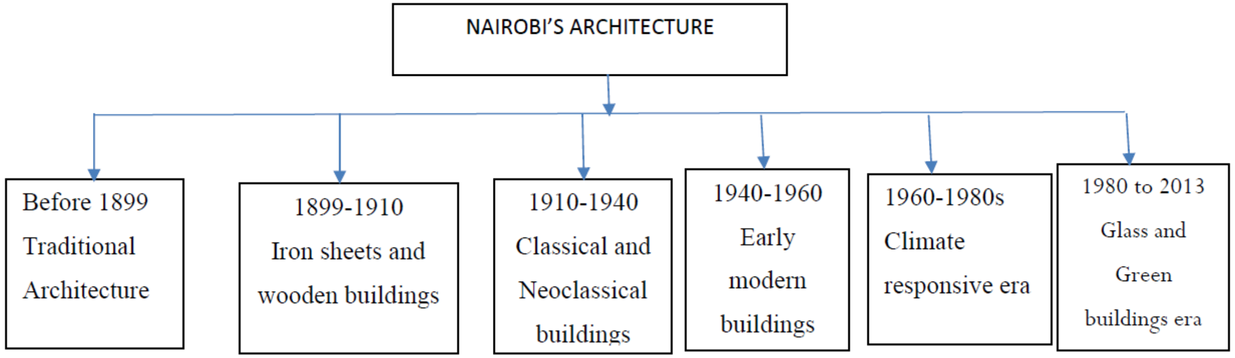


Figure 4: The evolution of Nairobi's built environment.
Source: Author

2.2.4 The adoption of green building technologies in Nairobi

The impetus to adopt green building standards in Nairobi has been accredited to the pressure exerted by international organizations to mitigate the adverse effects of buildings on environmental, social and economic systems of a particular region (Khaemba, 2014).

Green buildings are viewed as a hallmark of sustainable development and are often viewed as positive indicators of long-term economic, environmental and social health (Ali, 2000)

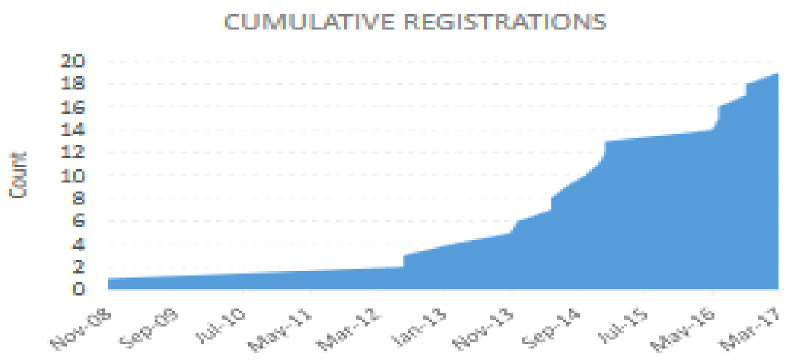


Figure 5: Growth of registered green projects in Kenya
Source: Author, (IFC - World Bank , 2018)

In addition, green building design and technologies have been introduced and marketed to stakeholders are cheaper and more resource efficient than the alternative. Green buildings have also been marketed to stakeholders as being water efficient, energy efficient, made of non-toxic materials and because of these factors they have enhanced market value and reduced operation costs.

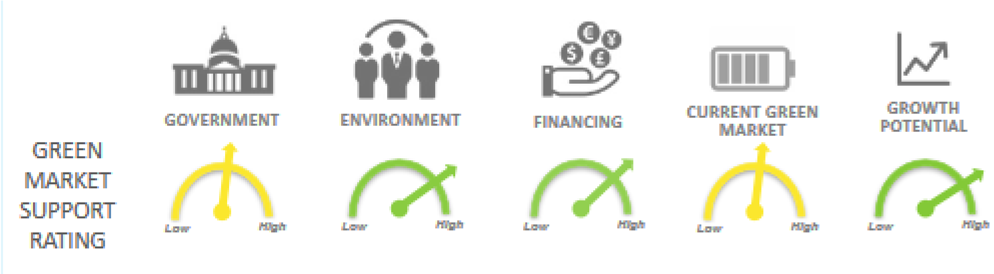


Figure 6: An overview of Kenya's green building market.
Source: Author, (IFC - World Bank , 2018)

Stakeholders have been enticed by studies that evidence the economic viability of adopting green building technologies or standards. One such study conducted by Kats et. al (Kats, 2003) revealed that the financial benefits of green buildings are ten times their primary costs.

2.2.5 Justification for the adoption of green building rating systems in Nairobi

Though the incorporation of GBR tools is not required by Kenyan law, the principles on which they are designed are reflected in some local statutes, regulations and policies. Green building rating systems promote and encourage sustainable building design and construction and this in turn facilitates the countries sustainable development. The Constitution of Kenya 2010 in Articles 10(2) (d) and 42 requires Kenyans to promote and instill the values of sustainable development and to conserve, manage, utilize and natural resources in a sustainable manner that is respectful of everyone's inalienable right to a clean and healthy environment.

The use of GBR systems is also congruent with provisions of the Environmental Management and Coordination (Act 2012) that require the building owners to conduct environmental impact assessments and annual environmental audits on the buildings they create. The adoption of green building technologies, standards and rating systems can also be clearly linked to the sustainable national development envisioned in the Kenya Vision 2030 strategy, especially as it relates to the provision of sustainable housing for Kenyans and conservation and protection of the environment (Government of Kenya, 2015).

Green building rating systems contribute significantly to the development of best practices in the building construction and design industry. By authenticating the green nature of a project or a building , GBR systems clearly delineate the sustainability standards that need to be adhered to by stakeholders enabling them to make informed choices when purchasing products, selecting building sites or deciding on which building design to adopt. This enhanced level of certainty and clarity makes it easier for owners of green buildings to carry out a self assessment of their buildings prior to consulting with green building rating professionals.

Certification of green buildings provides an incentive to prospected occupants who are environmentally conscious to take up tenancy in these buildings. As international and local organizations adopt environmentally friendly policies and objectives, they also demand that the office spaces that they work in reflect these environmentally friendly policies and aspirations. Green building certifications can be used as marketing tools to attract potential tenants or buyers to occupy these green buildings. A prime example of an environmentally conscious client is the World Bank that required that their headquarters in Nairobi at the Delta Center in Nairobi must be a certified green building. The Delta Towers is a local green building that was awarded with gold certification after evaluation using the LEED GBR system.

GBR systems are also important because they build on the existing body of knowledge in relation to sustainable building design and construction. The use of green rating systems encourages multidisciplinary engagement with practitioners and academics of green building technologies. As an educational tool, green building rating systems are able to indicate shortcomings in existing green building strategies, standards and concepts and in so doing reveal prospective avenues for research and review.

2.2.6 Challenges facing the adoption of green building rating systems in Nairobi.

Since the introduction of green building technologies and standards into the Kenyan market almost three decades ago, several challenges have arisen to hamper their successful integration and adoption. Addressing these challenges will require the concerted collaborative effort of all stakeholders in the building design and construction industry. This section of the study discusses three key challenges and proposes some approaches that may mitigate the negative impact that they occasion.

The first hurdle that has yet to be overcome is the unfavorable perception of local built environment professionals on the adoption of green building technologies in the projects that they undertake. As a result of this negative perception, many architects and engineers are reluctant to recommend for the use of green building technology in their client's projects. The exact basis for this unfavorable perception was unclear until 2012, when 450 built environment professionals (such as architects, engineers, surveyors) were interviewed during the Kenya National Housing Survey to discover why they are reluctant to adopt alternative construction practices. Figure 7 below, illustrates the findings of the 2012-2013 Kenya National Housing Survey in this regard.

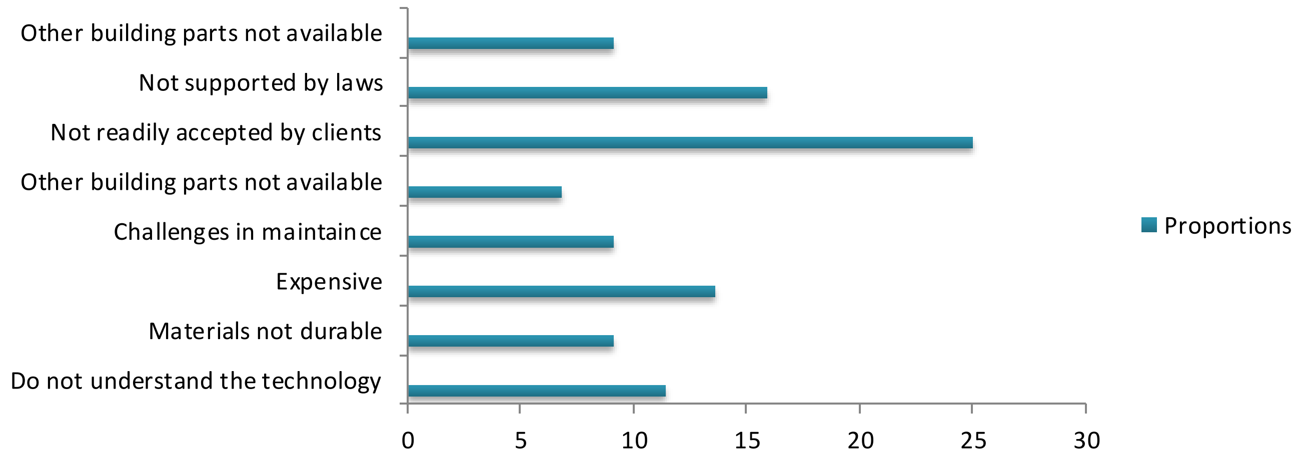


Figure 7: Proportional distribution of reasons why built environment professionals do not advice their clients to use alternative building materials and technologies.
Source: Author, Kenya National Housing Survey 2012-2013.

The second challenge that becomes apparent from Figure 7 above is the consumers' refusal to adopt alternative building technologies. This refusal may be caused by a lack of knowledge within the consumer base about green building technologies. Different construction projects have different green building design and construction needs. Careful consideration must be employed when choosing the appropriate green building technology to adopt. Without the necessary knowledge building owners are unable to make informed decision often causing them to opt not to adopt green building standards. Green building professionals and academics need to inform consumers on the advantages of adopting GBR systems and the need for sustainable building and design in relation to the conservation of Kenya's natural environment. Green building techniques and technologies should be incorporated into curricula and educational syllabuses used in the training of building design and construction practitioners. Yet another challenge that stakeholders face when opting to adopt green building technologies is the high cost of acquiring green building certification. As earlier mentioned, green building certification can only be obtained after the successful completion of green building assessment using the various regional or international green building rating systems.

The cost of certification under the BREEAM, LEED or Green Star global rating systems range between USD 1,469 and USD 14, 628. Taking into consideration the fact that building design and construction is a highly capital intensive endeavor, many building owners are reluctant to incur the additional cost of obtaining green building certification. This challenge may be addressed by designing and integrating local GBR systems such as the SGBI into the market and in so doing provide green building certification and accreditation at less cost to the consumer. Additionally the government could reduce the taxation imposed on the importation of building materials used for green building construction as further incentive for local construction companies to adopt green building techniques and technologies.

The integration of GBR systems and standards into building design and construction will require building owners to adhere to strict regulations as regards the building materials they use during construction. Most green building standards require building owners to use timber, building stones and other building materials that have been acquired sustainably and where possible sourced locally. Timber used in the construction of green buildings must be harvested sustainably and not in a manner that degrades the environment (Adeayo, 2000).

Materials used in building finishes such as paints and adhesives should not contain toxic elements that are harmful to human health. Adhering to these and other related requirements has proved problematic to many local building owners due to the local unavailability of building materials that meet these green building standards. This unavailability then compels local building owners to international markets to import the required materials at a greater cost (than they would incur if they had used cheaper nonconforming materials) and with greater difficulty. This challenge can only be addressed by the diversification of the local market to include the supply of building materials that comply to green building standards.

2.3 Green building rating systems used in Nairobi.

The choice of green building rating system utilized is dependent on several factors such as the nature of the project, the availability of funds, the availability of accredited professionals to conduct the assessment, the knowledge of the building's owners of green building standards and certification and so forth. The following section discusses the four green GBR systems currently in use in Nairobi County that are the subject of this study.

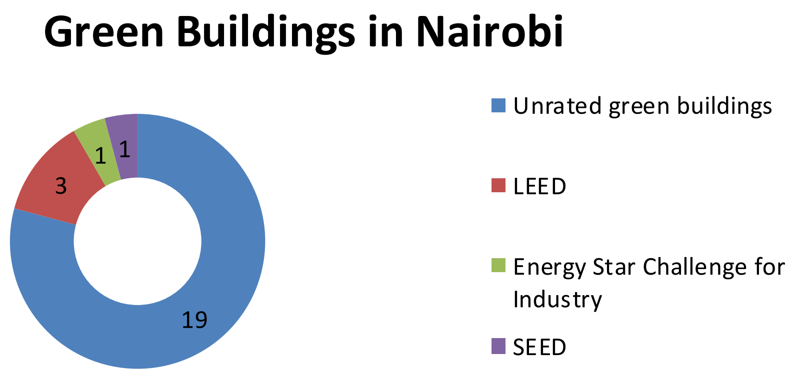


Figure 8: Green buildings submitted for rating in Nairobi by June 2018.
Source: Author, (IFC - World Bank , 2018)

2.3.1 The UK Building Research Establishment Environmental Assessment Method (BREEAM)

Developed in the United Kingdom in 1990, the Building Research Establishment Environmental Assessment Method (BREEAM) was the first green building rating tool to be used. Its initial geographical scope of application extended beyond the UK and extended to some European and Middle Eastern countries (Hedaoo and Khese, 2016). This adaptability was further enhanced by the flexible nature of this rating system as it takes into consideration local codes and conditions while at the same time making allowances for its application to international buildings (Marjaba G, 2016). By 2017, over 75 countries had adopted the BREEAM rating systems for the evaluation of green buildings in their territories (Ward C, 2017), and this number is set to increase in the years to follow. BREEAM provides for the evaluation of the entire lifecycle of a building from its design, construction and operation to its refurbishment (Building Research Establishment, 2019).

In the BREEAM rating system, assessment is expressed as a percentages of the total available points so that an award of 30% to 44% is given a Pass classification while an award of 85% and above is classified as Outstanding (Cheng and Venkataraman, 2013). BREEAM consists of nine categories namely; pollution (12 credits), energy (24 credits), management (10 credits), health and wellbeing (13 credits), waste (7 credits), transportation (10 credits), water (6 credits), material (13 credits), land use and ecology (10 credits) (Elmeligy and Mark, 2014). BREEAM uses a clear weighting system, whose combination differs depending on the type of the project. Although in all rating systems there is a provision for innovation design which is given few credits, BREEAM gives innovation more credits. Under the BREEAM green building rating system, energy is the most heavily weighted criteria with 17 points followed by health and wellbeing with 14 points (Waidyasekara and Rameezdeen, 2013). They are closely followed by management and materials with 11 points each.

Almost three decades after it was introduced, BREEAM has not only become widely accepted in the building design and construction industry, but has also influenced the development of successive green building rating systems used all over the world (Jabareen, 2009). In the year 1998 it was used in the United States of America’s LEED rating system that has also become popular (Khese *et al.,* 2016). This was closely followed by the introduction of the Green Star from Australia in 2002 and the Green (Ehsan *et al.,* 2013). Since its development, new international versions of BREEAM have been released and the latest version for certifying buildings worldwide (Awadh, 2017).

The BREEAM rating system is more adaptable to the local and regional context in East Africa since it is the most comprehensive green building rating system in terms of scope as considered from project registration, calculation to building certification. Additionally, the market initiation process of BREEAM adopts the bottom up approach which ensures its users are consulted before it is released to the market.

This is one of the key factors that have enhanced BREEAM's predominance in the market and its popularity amongst stakeholders in the building design and construction industries. One key shortcoming of BREEAM is that while its intention is to set the foundation for the development of essential sustainability standards as regards to factors such as energy, health or materials and facilitate their establishment, it does so at the expense of other factors such as water or waste which evidences a level of myopia to global changes that may occur in the future.

The table below highlights BREEAM's main features as discussed so far.

	Building Research Establishment Environmental Assessment Method (BREEAM)
Country of Origin	United Kingdom
Parent Organization	Building Research Establishment (BRE)
Global Adaptability	77 Countries
Latest Version	2016
Main Categories	Health and wellbeing Energy Innovation Land use and ecology Management

	Materials Pollution Waste Water
Rating approach	Pre-weighted categories
Rating level	Pass ≥ 30 Good ≥ 45 Very good ≥ 55 Excellent ≥ 70 Outstanding ≥ 85
Number of certified buildings by December 2018	567,005

Table 3: Features of the Building Research Establishment Environmental Assessment Method (BREEAM)
Source: Author, (Building Research Establishment, 2019).

2.3.2 The Leadership in Energy and Environmental Design (LEED) System

Leadership in Energy and Environmental Design (LEED) was developed using the consensus based approach by the U.S Green Building Council (USGBC) in the year 1998 (Hedaoo and Khese, 2016). It places great emphasis on the energy and atmosphere category by assigning it 35 points out of the 100 possible points. It is followed by sustainable sites and internal environmental quality categories with 26 and 15 points respectively (Khese *et al.*, 2016). The main objective of developing LEED was for it to analyze commercial buildings in the USA using green building standards (Awadh, 2017).

Since its launch, LEED green building rating system has been modified extensively to encourage its use outside the USA and to allow it to be customized to suit the needs of other regions (Reed et al., 2009). The most recent version of the LEED green building rating system is the 4.0 Version (2016) that is currently in use (Khaemba and Mutsune, 2014). LEED has become very popular of late due to the fact that it is an agreement driven Green building rating system whose market initiation process uses the bottom up approach, thus accepted easily and penetrates the market very fast (Etto and Ambiente, 2013).

LEED not only gives a brief outline of best practices in green building and environmental protection but also encourages the transfer of green building information, the use of innovative processes and the development of green building research (Feltes, 2007). It consists of seven basic categories which include; location and transport, sustainable sites, water efficiency, energy and atmosphere, material and resources, Indoor environmental quality and innovation in design (Gang and Li, 2012).

In order for a building to be LEED certified it has to meet the minimum program requirements (MPR) which are the five main categories which have the highest and different number of credits. These five categories and their credits are; energy and atmosphere (35 credits), sustainable sites (26 credits), indoor environmental quality (15 credits), materials and resources (14 credits)) and water efficiency 10 credits (Ehsan *et al.*, 2013).

LEED has a constant number of credits that offer points (110 points) across the seven categories. The credits do not change depending on the situation of the project being undertaken, credits are represented in the overall weighting even if they were inapplicable as a result of the project situation. The credit weighting process is frequently evaluated and modified to correspond to current needs of the subject region/ country as determined through scientific research and changes in market or industry trends (Say *et al.*, 2008).

The process of acquiring LEED certification requires the project's green building professionals to conduct an initial assessment of the building according to the categories provided and create an assessment report. Thereafter this assessment report is submitted to their respective country's Green Building Certification Institute (GBCI) for review and successive certification (Meiring, 2014). Scores are provided on a 100 credits scale with a possibility of additional 10 points coming from innovation. This means that the total possible number of credits that are attainable in LEED system is 110 Points (Bernardi and Carlucci, 2017). As per the LEED 2009, certification of new buildings or major renovations is classified as Certified (40-50 credits), Silver (50-60 credits), Gold (60-80 credits) and Platinum (80-110 credits) (Akadiri *et al.*, 2012). LEED global green building rating system is currently applicable to numerous building types such as offices, retail premises, religious institutions, academic institutions, hotels and homes with four or more stories (Fowler and Rauch, 2006).

The LEED Accredited Professional Program provides for green building rating of different types of building projects such as neighborhood development projects, new constructions, or core and shell renovation projects. This rating tool is flexible enough to suit the circumstances of different projects (Franzsen, 2002). Regardless of the customization or modification of LEED rating systems, they all retain the same categories and credit scoring system. This ensures accuracy of the rating tool and consistency in its application in different regions (Abdel and Khogali, 2016).

The table below gives examples of local green buildings, rated using the LEED system.

Project Name	**Location**	**Project Analyzed**	**Certification Dates**	**Certification Level**
Skynest Apartments	Nairobi, Kenya	New Construction		Silver

Forestscapes	Nairobi, Kenya	New Construction		Silver
Eaton Place	Nairobi, Kenya	Core and Shell	8th September 2015	Certified
Citibank Gigiri Branch and COB	Nairobi, Kenya	Commercial Interiors	2nd July 2015	Gold
World Bank Group – Delta Centre	Nairobi, Kenya	Commercial Interiors	28th May 2015	Gold
Al Jamea Tus Safiyah, Nairobi	Nairobi, Kenya	New Construction		Platinum

Table 4: Examples of LEED Certified projects in Kenya
Source: Author, (U. S. Green Building Council, 2019).

The LEED system has been used in many countries as a framework from which they developed their own green building rating tools (Khaemba and Mutsune, 2014). Despite its popularity the LEED system has been reported to be overly complicated and procedural and this hampers its adoption (Kiprotich, 2016). Although, 7% of the total number of points in LEED falls within the energy reduction category, they are determined through building a baseline model using baseline materials, orientation, window placement and fixtures and use. When rating the energy category in LEED, a model of a building should be build using the correct materials, windows and orientation and fixtures.

The initial version of LEED did not take into consideration the variations in climate of the different regions where it was used. The 2009 modification of this rating system attempted to resolve this shortcoming by creating a consultative process by which USGBC and its chapter volunteers identify LEED credits that should be prioritized to address specific regional issues. This process was referred to as 'regionalization'.

This process resulted in the identification of various regional zones and allocating each of them with regional priority credits and associated priority credits. For example the thermal comfort levels in tropical regions such as the East African region differ widely from those in temperate regions (like in Europe) and thus significantly reduce the costs expended on air conditioning.

The table below highlights LEED's characteristics as discussed so far.

	Leadership in Environmental and Energy Development. (LEED)
Country of Origin	The United States of America
Parent Organization	The US Green Building Council
Global Adaptability	≥165 Countries
Latest Version	2013
Main Categories	Indoor environmental quality Sustainable sites Water efficiency Materials and resources Energy and atmosphere
Rating approach	Additive credits
Rating level	Certified ≥ 40 Silver ≥ 50 Gold ≥ 60 Platinum ≥ 80
Number of certified projects by December 2018	≥94,000

Table 5: Features of the Leadership in Energy and Environmental Design (LEED) rating system.
Source: Author, (U. S. Green Building Council, 2019)

2.3.3 The Australian Green Star System.

This is a green building rating system launched in Australia in year 2003 by the Green Building Council of Australia (GBCA) (Hedaoo and Khese, 2016). The Green Star rating tool gives priority to a broad range of sustainable aspects of the construction sector with the intent to minimize the adverse effect built structures exert on the environment, improve the productivity levels and health of occupants and communities, and minimize on the costs incurred, while carrying out innovation in sustainable building practices. The Australian Green Star rating tool has nine categories which includes; management, indoor environmental quality, energy, transport, water, materials, land use, emissions and innovations (GBCA, 2013). The emission category together with the transport category are given the heavy weights in the Green Star rating system with 19 and 11 points given to each respectively (Awadh, 2017). Since its launch, thousands of green buildings all over the world and especially in Australia, South Africa and New Zealand have been certified using this tool (Ehsan *et al.,* 2013).

A study carried out in May 2013 by the Green Building Council of Australia analyzed 428 Green Star certified projects to establish the environmental benefits of using the Green Star Rating system established that buildings with high Green Star ratings (that is 4, 5 or 6 star) reported less financial and environmental costs of construction and maintenance (GBCA, 2013). The Green Star rating tool is currently available for rating a variety of buildings such as retail centers, schools, industrial buildings, apartment buildings, hospitals, offices and public buildings (Khese *et al.,* 2016).

To meet the demands set by the Australian Green Star rating system, building professionals must submit the required information derived from design plans and construction data to an independent assessment team who will review the information (Goosen, 2009). Each green building project submitted for certification under the Australian Green Star system must be subjected to an initial self-assessment of a building's compliance per each category's specifications. After this assessment of a building according to the nine categories of the Australian Green Star system, the independent assessment panel will validate the scores, render a decision and award the building with the applicable certification.

Certain specific mandatory requirements have to be met before a building can be granted Green Star certification. Australian Green Star awards are percentage based with an award of 4 stars given for best practice (45-60%), 5 s and 6 stars signifying world awarded for leadership status (75-100%) (Meiring, 2014b).

The following table shows local projects rated under the Green Star system.

Project Name	Location	Rating system
Garden City Residential Phase 1	Nairobi	Greenstar Multi unit residential V1
Garden City Residential Phase 2A	Nairobi	Greenstar Multi unit residential V2
Garden City Residential Phase 2B	Nairobi	Greenstar Multi unit residential V3
Dunhill Towers	Nairobi	Greenstar office V1.1

Table 6: Projects in Kenya rated using the Green Star system.
Source: Author, **(Kenya Green Building Society (KGBS), 2018)**

Notably, the Australian Green Star rating system allows for the weighting of different categories to be modified by altering the allocation of credits to suit the needs of a particular country based on their importance to the circumstances of each country. This flexibility increases the Green Star's accuracy when evaluating green buildings. (Khaemba and Mutsune, 2014). Consequently, the Green Star has a high level of adaptability to other environments or regions outside Australia (Meiring, 2014b).

The table below highlights the key characteristics of the Green Star rating system as discussed so far.

	The Australian Green Star Rating System (Green Star)
Country of Origin	Australia
Parent Organization	Green Building Council of Australia (GBCA)
Year of origin	2003
Latest Version	2010
Main Categories	Indoor Environment Quality Energy & Emissions Innovation Transport Land use and ecology Materials & Water
Rating approach	Additive Points
Rating level	1 Star – Minimum Practice (10-19%) 2 Star – Average Practice (20-29%) 3 Star – Good Practice (30-44%) 4 Star – Best Practice (45-59%) 5 Star – Australian Excellence (60-65%) 6 Star – World Leadership (75-100%)
Number of certified projects by December 2018	2,244

Table 7: Features of the Green Star System

Source: Author, (Green Building Council of Australia (GBCA), 2019).

2.3.4 The Safari Green Building Index (SGBI)

With the green building movement's continued entrenchment into the real estate industry, there had been no green building guidelines developed specifically for Kenya and the East Africa region as a whole; consequently stakeholders in this region continued to rely on international sustainable building rating systems such as the United Kingdom BREEAM, the USA LEED and the Australian Green Star as guided by accredited professionals (Khaemba and Mutsune, 2014). Nevertheless, there was apparent interest from the relevant stakeholders to develop a local GBR system suitable for the East Africa region (Franzsen, 2002). Regional green building standards such the Australian Green Star, LEED and BREEAM were formulated to meet the environmental and climatic conditions of their respective regions, and based on this underlying principle, were insufficient to effectively address the building design and construction requirements of the East African region whose environment and climate differ widely from that in the USA, UK and Australia (Khaemba and Mutsune, 2014).

A team of experts from the Environmental Design Chapter of the Architectural Association of Kenya (AAK), the Green Africa Foundation, the University of Nairobi and UN-Habitat have developed a GBR tool for the East African region known as the Safari Green Building Index (SGBI). The SGBI was intended to provide a green building rating tool that is suitable to address the environmental, social, developmental and economic concerns of region's construction industry. To achieve this, the SGBI incorporates sustainable development ideals and processes in building design and construction so as to mitigate the negative effects that buildings exert on the region's environment.

The SGBI was designed for rating all types of buildings in Kenya and other countries experiencing similar climatic conditions. This locally developed rating tool was intended to give a holistic approach to the evaluation of green buildings in East Africa beginning from the building design stage all the way to the refurbishment of preexisting buildings. The SGBI is conscious of the role of stakeholders in the industry and sets standards for building design, operation, management, occupancy. It takes into consideration the unique socio-economic and climatic characteristics of the East Africa region when rating buildings in the region and hence is ideally better suited for application in this region than other global green building rating tools e.g. the Australian Green Star, LEED and BREEAM.

The SGBI was developed on the underlying principles entailed in the international body of green building rating systems such as LEED, BREAM, GRIHA, the Australian Green star, Green Mark and further enhanced by the incorporation of information gained from extensive consultations with technical experts and stakeholders in the industry. The main aim of the Safari Green Building Index is to establish environmental conscious best practices for building design and construction the planning, design and construction of buildings in Nairobi and the entire East Africa region as a whole.

As a regulatory tool created to protect and conserve the natural environment, the SGBI facilitates the assessment of construction projects as regards the extent to which they impact the environment, utilize available natural resources such as water or energy and dispose of waste matter. It takes into account the provisions of the Constitution of Kenya 2010, the Physical Planning Act 2012, the Environment Management and Co-ordination Act (EMCA) of 2012, National Building Regulations 2014, local and international Building Codes, regulations and international codes, conventions and standards. The SGBI provides for the analysis of the environmental performance of projects in the build environment and provide leadership in sustainability through reducing a building's reliance on non-renewable energy sources, minimizing pollution of the environment and maximizing on the efficient use of raw materials. It is envisaged that it will fill the existing regulatory gap in the achievement of sustainable green buildings in Nairobi and the entire East Africa region.

The SGBI rating tool employs a percentage based rating system in which points are earned out of the highest possible score of 100 for meeting the design and performance intent of each respective category. Each category has a number of points assigned to it as follows: prerequisite requirements 0%; the building landscape 5%; passive design strategies 45%; energy efficiency 10%; resource efficiency 30%; noise control and acoustic design 5%; and innovation 5%. These categories are further broken down into subcategories each with an assigned number of points attainable. The building is assessed under all the categories and the points are added up and calculated as the percentage of the total number vis-à-vis the highest possible score of 100.

The SGBI rating system provides for a total of 100 points. Each of the seven categories have a certain number of points assigned to them. Some of the categories are core to the rating system and as such have a higher number of points assigned to them while others are supplementary and have fewer points. The SGBI uses the same certification method as other international green building rating systems as follows: 'Class **D**' = 'two stars' or bronze; 'Class **C**' = 'three stars' or silver; 'Class **B**' = 'four stars' or Gold; 'Class A' = 'five stars' or Platinum.

The SGBI ranking system has five ranks. Each rank denotes the maximum and minimum number of points a building needs to have in order to attain it. A building under assessment needs to have at least **50** points to qualify for ranking under the SGBI systems.. The five ranks of the SGBI system are as follows:

1. Non - Green Buildings: 0 to 50 points,
2. Class **D** Green Building: 50 to 59 points,
3. Class **C** Green Building: 60 to 69 points,
4. Class **B** Green Building: 70 to 79 points,
5. Class **A** Green Building: 80 to 100 points.

.

The table below illustrates the key features of the Safari Green Building Index.

	Safari Green Building Index (SGBI)
Country of Origin	Kenya
Parent Organization	Architectural Association of Kenya (AAK)
Year of Origin	2014
Main Categories	Prerequisite requirements Building landscape Passive design strategies Energy efficiency Resource efficiency Noise control and acoustic design Innovation
Rating approach	Pre-weighted categories
Rating level	Non- Classified ≤ 50 Class D' = 'two stars' or bronze ≥ 51 Class C' = 'three stars' or silver ≥ 61 Class B' = 'four stars' or Gold ≥ 71 Class A' = 'five stars' or Platinum. ≥ 81
Number of certified buildings by December 2018	0

Table 8: Features of the Safari Green Building Index (SGBI).
Source: Author

2.3.5 Comparison of the three global green building systems

There exist major differences between these three green building systems. For example each of these three green building systems has a certification process that is dissimilar to the other with BREEAM having 6 steps that need to be undertaken before a building can be certified while LEED has 8 steps and the Australian Green Star has 9 steps. (Bernardi and Carlucci, 2017). The ranking system for each of them also differs with LEED having a medal system (platinum for high rating buildings and bronze for low rating buildings), the Australian Green Star uses an ordinal ranking system (with 6 denoting a high rating building and 1 a low rating building) and finally in BREEAM, green buildings with high ratings are graded as Excellent while low rating buildings are graded as Pass (Khaemba and Mutsune, 2014).

There is also variation in category weightings; BREEAM places a greater emphasis on materials, land use and emissions while LEED places higher importance on management and energy whereas Green Star prioritizes indoor quality and water (Franzsen, 2002). BREEAM exceeds the other systems when it comes to the consideration of general human health and wellbeing issues since it has a category for health and wellbeing which is assigned 13 credits while the other two do not (Ehsan *et al.*, 2013). As a result of the severe, prolonged drought experienced in Australia the Australian Green Star was modified to emphasize the need for water conservation in green buildings and increased the number of compliance requirements to a much higher level than the other two green building rating systems (Say *et al.*, 2008).

It is also of great importance to note that LEED and Green Star certifications are not regarded to be at par with those of BREEAM. For example, a Six Star rating of the Green Star rating system, which is the highest Green Star rate achievable, is still considered less sustainable than a Platinum level LEED rating (the highest LEED rating possible) and is further considered to be approximately equal to a very good BREEAM rating (Say *et al.*, 2008).

One of the key similarities between the three international green building rating systems is that they all promote best building practices for environmental protection and sustainable development (Akadiri *et al.*, 2012).Further all them use a credit based system with some flexibility in which aspects building developers or investors want to focus on, together with other mandatory requirements that must be met before certification (Khese *et al.*, 2016).

All green building rating systems in use today are heavily influenced by the preexisting building construction legislation, codes and regulations of the country or region where they were developed. These codified building construction rules are intended to address each individual region's or country's social, climatic, geographical, economic, developmental, administrational needs and circumstances as well as to encourage best practices in the construction sector and ensure building sustainability(Park *et al.*, 2017).. These unique building construction regulations often form the foundation of GBR systems. Countries with similar economic, environmental and social geographies can share a building rating tool and still achieve building sustainability in terms of performance (Gang and Li, 2012).

With this in mind, making a comparison between two or more green building rating systems may only be done after acquiring a full appreciation of the specific circumstances of their (the rating system's) country/ region of origin (Akadiri *et al.*, 2012).For instance, some countries have lax building construction laws, codes or regulations and this laxity is reflected in the green building rating system developed in these countries; while the reverse is true in countries where the building construction is strictly regulated (Sinha and Gupta, 2013). Therefore organizations wishing to use one green building rating system to evaluate properties in different regions ought to be careful to ensure that doing so does not prejudice those buildings outside the rating system's country of origin (Fowler and Rauch, 2006).

The following table illustrates the key differences between the Green Star, LEED and BREEAM global green building systems.

	BREEAM	LEED	Australian Green Star
Date Launched	1990	1998	2003
Ratings system	Pass, Good, Very Good, Excellent, Outstanding	Platinum, Gold, Silver, Bronze	Star rating system (1 to 6)

Weightings	Applied to each issue category (consensus based on scientific or open consultation)	The total number of credits assigned to each category is equal to the weight assigned thereto.	Applied to each issue category (industry survey based)
Information Gathering	Competent assessor, design team or management team	Accredited professionals, management or design team.	Design team
Certification labeling	BRE (Building Research Establishment)	USGBC (United States Green Buildings Council)	GBCA (Green Building Council of Australia)
Building & Site aspects examined	Management (MAN) ,Health & Wellbeing (HEA), Energy (ENE), Transport (TRA),Water (WAT), Materials (MAT), Waste (WST),Land Use (LE) and Pollution (POL)	Location and Transportation (LT), Sustainable Sites (SS) ,Water Efficiency (WE) ,Energy and Atmosphere (EA) , Materials and Resources (MR), Indoor Environmental Quality (EQ), Innovation (IN), and Regional Priority (RP)	Management, Indoor environmental quality, Energy, Transport, Water, materials, Land use, Emissions Innovations
Third-Party Valuation	BRE (Building Research Establishment)	N/A	GBCA (Green Building Council of Australia) nominated assessors
Managing Organization	BRE (Building Research Establishment)	USGBC (United States Green Building Council)	GBCA (Green Building Council Australia)

Academic qualifications	Enrolment into a scheme of competent persons	A grade of Pass and above in the exam	Attendance of training schemes and a grade of Pass + in the examinations
Practical qualifications	Assessors must conduct 1+ assessment yearly.	None	Assessor's status reviewed every 3 years
Access & availability of information	Assessment tools and information available at no cost.. Technical assistance available for attendees of training courses.	Assessment tools and information available at no cost. Technical assistance may be acquired for approximately Kes. 20,000 (USD 200)	Assessment tools and information available at no cost. Additional technical information is provided in manuals that cost approximately Kes. 44,400 (USD 444)
Certification fee	$1469– 2979	$2250– 22500	$5063– 14268
Update timelines	12 months	On an as-needed basis	12 months

Table 9: Comparison of the Australian Green Star, LEED and BREEAM green building rating systems.
Source: Adopted from Reed *et al.* (2009)

2.4 Conceptual Framework

A Conceptual framework can be defined as a body of statements that is organized in such a manner as to create a greater understanding of a research study's objectives or goals (Jabareen, 2009). The statements contained in the conceptual framework are essentially interconnected ideas that articulate a particular phenomenon or support a philosophy – that forms the basis of a study (Solomon, 2010). This framework is an essential research tool that allows readers and researchers to gain a basic understanding of the subject parameters delineating the research study (Jabareen, 2009).

As revealed through this study, buildings that adopt green building technology bring about positive direct and indirect impacts on people's health, environment, physical resources and energy. Establishment of green buildings is highly determined by the initial costs, cost in use and the recovery costs. Adoption of green building technology is also influenced by the willingness of the people, national and county governments to implement them hence the need for constant review of these technologies.

By implementing green building technology practices, environmental sustainability, enhancement of local skills and knowledge, improved human health and increased conservation of physical resources will be realized. Consequently, greater opportunities that will shape the economic environment in which many people operate and work will be created.

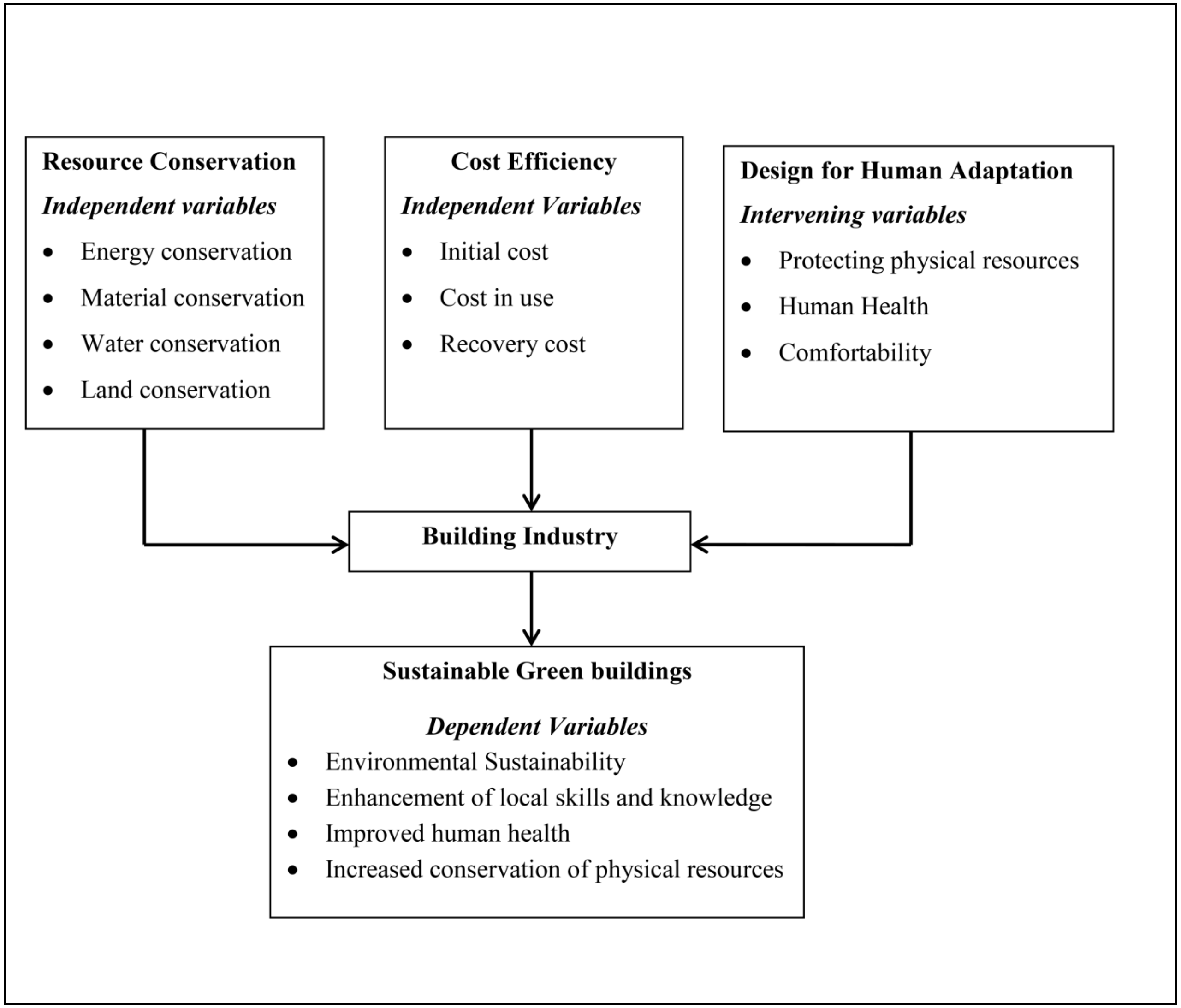
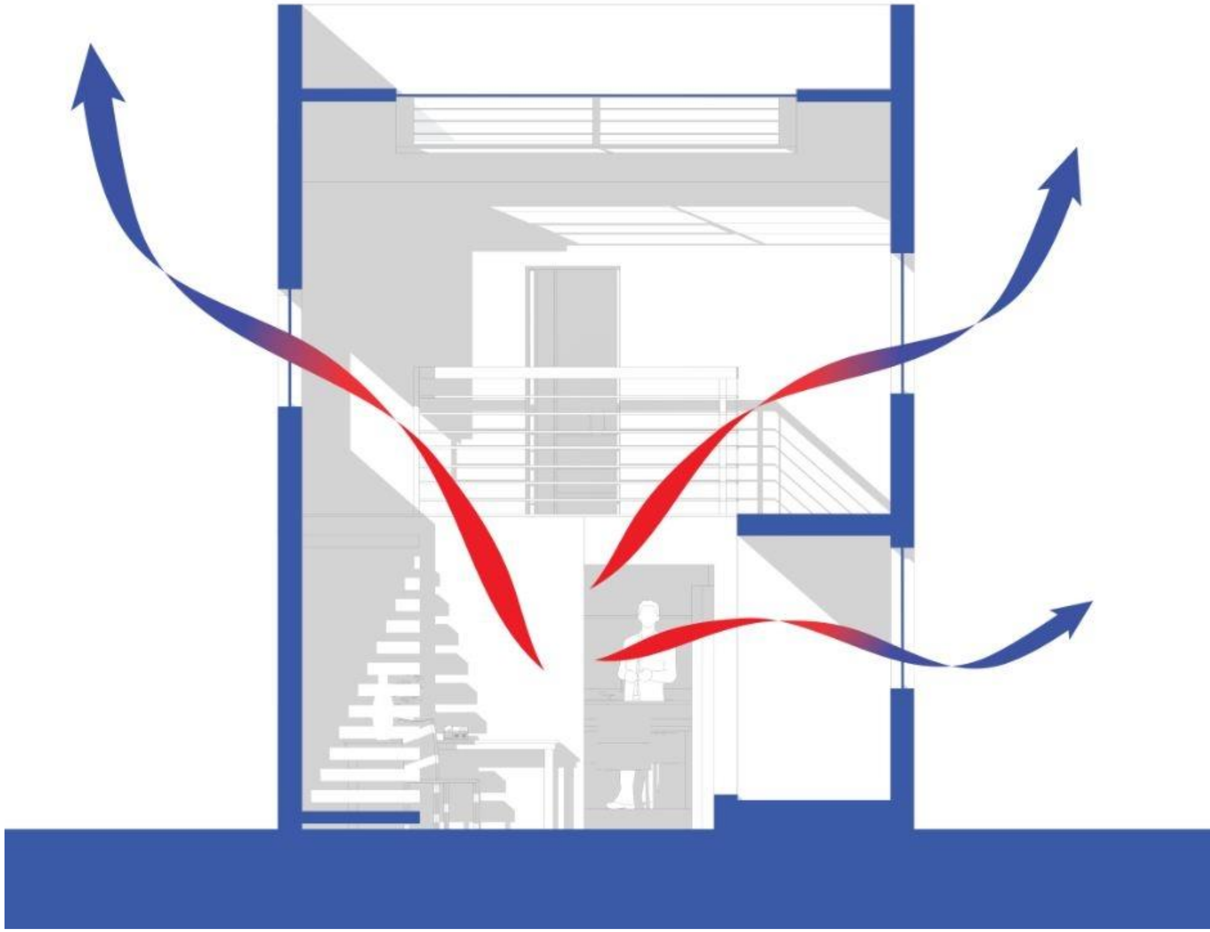


Figure 9: A Conceptual framework for Green building technology.
Source: Adapted from Akadiri *et al.*, (2012)

CHAPTER THREE: RESEARCH STUDY DESIGN AND METHOD



CHAPTER THREE: RESEARCH STUDY DESIGN AND METHOD

This chapter encapsulates the research design and methodology used to realize the purpose of this study. The first section provides the research design used in the study while the second section provides the methodology which was applied. Included in the methodology is the sampling procedures and sampling size, data collection methods and data analysis techniques.

3.1 Method of Research

In order to address this study's research questions, correct methodology was followed and suitable tools for data collection used (Rahi, 2017). The researcher decided to limit the number of GBR systems used to evaluate the three buildings selected for analysis in this study to two because the time and financial resources available to him were insufficient to conduct a comprehensive green building rating exercise using all four green building systems discussed in this study (that is SGBI, LEED, Australian Green Star and BREEAM).

Of the international GBR systems, the researcher elected to use the Green Star rating system as a representative of international rating systems in use in Nairobi for purposes of making the comparison between international a green building systems and the SGBI. The researcher's decision was informed by the consideration of the fact that of the three international green rating systems, only the Green Star rating system had been formally adopted regionally following the grant of license to South Africa in 2008 that allows the Green Building Council of South Africa (GBSA) to certify green buildings throughout the African Continent.

This research study then subjected three buildings located in Nairobi County to GBR using the Green Star- SA Kenya rating system and the SGBI. These buildings were the Garden City Village Phase 1- Residential Building, the University of Nairobi Towers and the Strathmore Business School building in Strathmore University. Both quantitative and qualitative data was utilized to measure certain parameters such as occupant comfort, daylight availability and re-use of materials. Structured and semi structured questionnaires, field observations, interviews, checklists and photography were used to collect this type of data.

3.1.1 Unit of Analysis

Unit of analysis becomes important when the researcher is attempting to draw a sample to work with from the target population (Earl, 2013). The unit of analysis also known as the sampling unit in this study refers to the person or building that provides relevant data. Whilst the data that each unit provides primarily relates to the unit specifically, when similar data units are considered collectively, such consideration can be used to infer certain aspects of the population that unit belongs to (Klein and Foss, 2009). In this research work, the units of analysis were the relevant institutions dealing with green buildings such as the Kenya Green Building Council, architects, engineers, quantity surveyors, sustainable buildings consultants, landlords, land owners, tenants and property managers of the Garden City Village Phase 1 -Residential Building, the Strathmore Business School building in Strathmore University and the University of Nairobi Towers in Nairobi County.

3.2 Sampling Procedure

As recommended by Mugenda & Mugenda (Research Methods, Quantitative & Qualitative approaches, 1999), a minimum sample size of 60% of the target population and a maximum of 75% is preferred for any study to be representative of the whole population. This research did not adhere to this recommendation but instead focused its analysis on three preselected buildings rated using one international GBR system (the Green Star – SA Kenya system) and one local GBR system (the Safari Green Building Index).

The Garden City Village Phase 1 Residential Building was selected for green building rating in this study because the building had already been awarded with Green Star SA- Kenya certification and was therefore a perfect candidate for green building analysis using the SGBI for purposes of comparing the two green building rating systems. The University of Nairobi Towers and the Strathmore University Strathmore Business School building were selected for green building assessment in this study because despite being uncertified, they are widely considered to be two green buildings built by educational institutions.

Both the University of Nairobi and Strathmore University have repeatedly reiterated their commitment to realizing the ideals of sustainable development in Kenya and the use of innovation to incorporate the development of environmentally friendly solutions to the nation's problems. The design and construction of both the University of Nairobi Towers and the Strathmore Business School building was intended to reflect these lofty ideals. Therefore by subjecting these two buildings to green building rating using two different green building systems the researcher intended to determine whether or not they have met all the necessary requirements to be considered to be green buildings while at the same time to bring out the difference between international GBR systems and locally developed GBR systems. The researcher also involved the tenants, managers/owners, architects, sustainable buildings consultants and engineers of the three buildings selected in the conduct of this study.

3.2.1 Sampling procedure and sample size

Sampling procedure is a systematic process of selecting a number of items or individuals from the entire population in the study area to be used in the research work as the representative of the whole population (Kulshreshtha, 2013). The selected items should contain characteristics which represent the whole population covering the study area (Guetterman, 2015). The following sampling techniques were used in this study;

3.2.1.1 Purposive sampling technique

This sampling technique is best used for the identification of individuals or units to be used in a research study in situations where these individuals or units have peculiar characteristics relevant to the study's objectives (Tongco, 2007) .A researcher who employs this sampling technique does so with regard to this particular aspect of the individuals studied without being limited by their relative size to the larger population. (Palinkas *et al.*, 2015). In this study purposive sampling was used to collect data from the relevant institutions, architects, engineers, quantity surveyors, sustainable building consultants, landlords, land owners, tenants and property managers managing the selected buildings, that is, Garden City Village Residential Building Phase 1, Strathmore Business School building in Strathmore University and the University of Nairobi Towers.

3.2.1.2 Simple random sampling

Simple random sampling affords all persons or units of a particular population relevant to a study an opportunity to participate in the study without the decision to do so causing an effect on other units in the study population (Utara, 2011). In this study simple random sampling was not applicable since the researcher identified three buildings that would be the subject of this study. The first building was Garden City Village Phase 1 Residential Building which was already formally rated and certified using the Green Star rating system. The remaining two buildings selected for analysis in this study were the Strathmore Business School building in Strathmore University and the University of Nairobi Towers. Their architects, consultants, engineers, tenants, owners and managers were then interviewed to get more information concerning the buildings.

3.3 Data need matrix

The table below illustrates the data that was used to successfully achieve the objectives of this study.

	Data Needed	Data collection methods	Source
Objective 1	• Data on the environments for which BREEAM, Green Star and LEED were made for. • Data on categories of LEED,BREEAM and Green Star • Data on priority categories in BREEAM, Green Star and LEED.	• Questionnaires • Interviews • Previous literature on LEED, BREEAM and Green Star	• Kenya meteorological department • Ministry of lands and Housing • GIS integration • Ministry of Environment, Water and natural resources • Review of literature on LEED, BREEAM and Green Star
Objective 2	• Data on Categories in SGBI • Data on certification process of safari • Data on people's perception (What has not been captured by other GBS but addressed by SGBI) • Architectural drawings	• Checklists • Questionnaires • Observations • Drawings and plans	• Ministry of lands and Housing • Architects • KGBS • County Government of Nairobi • Engineers • Tenants • Land owners (Property managers)

Objective 3	• Certification results of LEED, BREEAM and Green Star (case study buildings). • Certification results for safari (Case study buildings) • Architectural drawings • Data on perception of the comparison between performances of safari to other green building systems.	• Questionnaires • Interviews • Observation • Electronic gadgets (Cameras)	• Architects • Engineers • Property managers • County Government of Nairobi • KGBS • Quantity surveyors • Ministry of Environment, water and natural resources • Property managers

Table 10: Summarized Data Need Matrix
Source: Author, 2018

3.4 Data collection

Due to the nature of this study both quantitative and qualitative data from primary and secondary sources were used. Structured and semi structured questionnaires, field observations, interviews, checklists and photography were used to collect data which was used to fulfill the objectives of this study.

3.4.1 Questionnaires

A questionnaire is a tool used for collection and recording of information related to a particular topic which the researcher is interested in (Utara, 2011). The list of questions contained in the questionnaires should seek to provide answers to the research questions and the respondents should be made aware what the research is all about, when and how they will receive the findings of the study (Earl, 2013). Both open-ended and closed ended questionnaires were used. This method was used to collect data from the Green buildings owners, tenants and key informants (Architects, engineers, sustainable building consultants and property managers) from relevant institutions using institutional questionnaires. The data collected focused majorly on the five categories in Green Star and Safari green building index.

3.4.2 Observation

Observation involves measuring directly the characteristics the research is interested in while in the field or laboratory (Stahl *et al.*, 2012). Flexibility is needed in observation in order to observe the key components the researcher intends to see (Driscoll, 2011). Observation was applied to examine daylight availability, general aesthetics of the buildings, shading in the buildings, ventilation of the building, materials used to construct the buildings and disruptions on the buildings.

3.4.3 Photography

Photography is a data collection method in situations where there is physical evidence of existence, items and outcomes that can be easily seen (Ownby, 2013). Digital cameras were used to collect data; the data included some of the physical characteristic of green buildings such as; types of shades in the buildings, trees within the buildings vicinity and indoor aesthetics of the buildings and also photographs of the buildings, that is, Garden City Village Phase 1 Residential Building and the University of Nairobi towers.

3.4.4 Interviews

Due to its cost effectiveness and strength in acquiring empirical data the interview method was used to collect data for this study partly (Kothari, 1990). Interviews were used to gather first-hand information from key informants (Architects, engineers, property managers and property owners) and relevant institutions (ministry of lands and housing, ministry of environment, water and natural resources and the county government of Nairobi) through use of interview schedule

3.4.5 Inspection Checklist

An inspection checklist that defines safari green building index categories from the heaviest weighted to the least weighted was used to rate Garden City Village Phase 1 Residential Building which was rated using green star. Inspection checklist for both Safari and Green star were used to rate the University of Nairobi towers which are not yet certified. The checklists were helpful in collecting data pertaining the all categories found in Safari and Green Star.

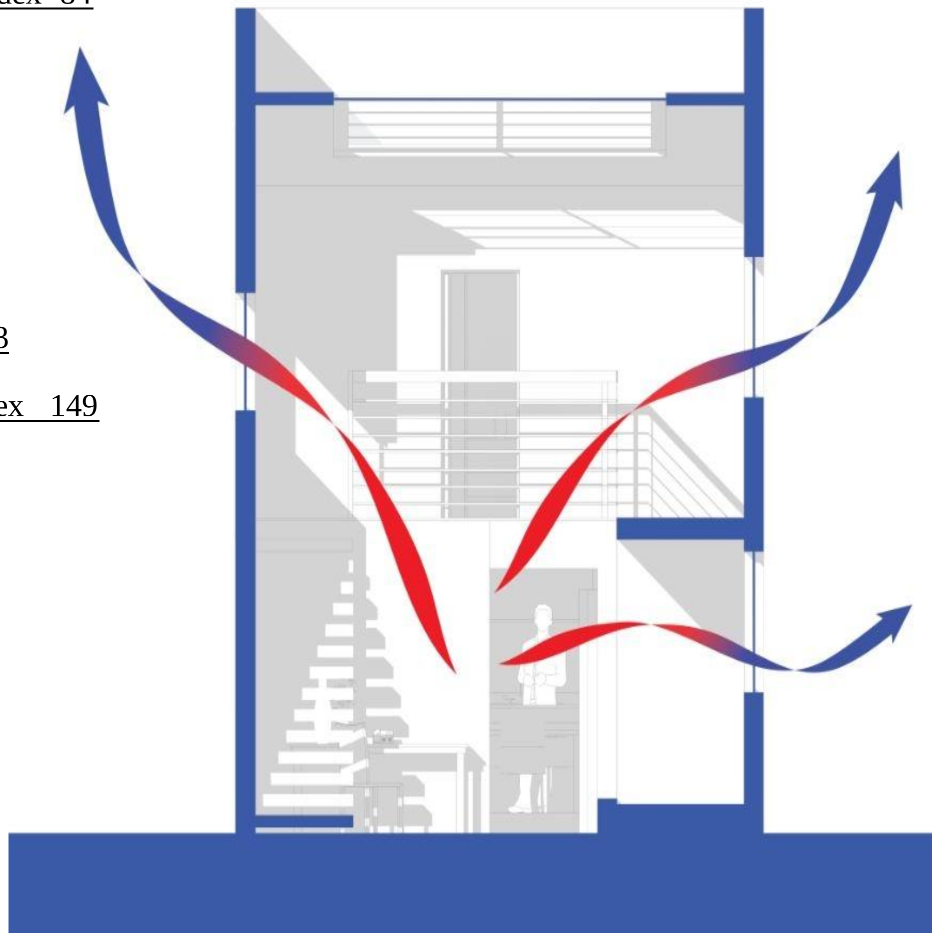
3.4.6 Focused Group Discussion

According to Dilshad and Latif, (2013), Focused Group Discussion (FGD) is an in-depth interview with a group of people sharing the same experience and understanding with regard to a situation or event. Focused group discussions was not undertaken in this study due to lack of enough time and resources to coordinate the groups. Also the fact that the study majored on key informants such as architects, engineers, sustainable buildings consultants and property managers to get the required data made it difficult to get them in a one sitting hence focussed group discussion wasn't applicable in the study.

3.5 Data analysis

Both quantitative and qualitative description techniques were used in the analysis of the data collected from the field. The quantitative data in the questionnaires was edited, coded and then subjected to descriptive statistics in the Statistical Package for Social Scientists (SPSS) software. The data in the inspection checklists was analysed using both quantitative and qualitative methods for comparison purposes. Frequencies, percentages and means were generated and the final results presented in charts, tables, graphs and figures as discussed in Chapter 4. The answers to open ended questions from the questionnaires, observation, interviews and photographs were keenly arranged , sorted and coded descriptively into themes and the answers presented in narrative and discussion form.

CHAPTER FOUR: DATA COLLECTION AND ANALYSIS



CHAPTER FOUR: DATA COLLECTION AND ANALYSIS

4.1Introduction

This chapter presents the data that was obtained following the rating of the Garden City Village – Phase 1 Residential Village, the University of Nairobi Towers and the Strathmore Business School building in Strathmore University using the Green Star rating system and the Safari Green Building Index. It further contains a summary of the findings of this study.

4.2 Garden City Village Phase 1 Residential Building

Garden City Village Residential building Phase 1 is located along Thika Road, Nairobi. The residential property is made up of 77 three bedroomed residential units and has a total gross floor area (GFA) of 15,113 m^2. It was designed by Triad Architects in Nairobi and developed by ACTIS. The properties compound has a variety of tree species. All units in the building are cooled by natural ventilation. The residential property was rated using Green Star Africa-Kenya and it emerged to be a 4 star rated building with a total of 46 points. Nine categories namely; management, indoor environmental quality; energy; transport; water; materials; land and ecology; Emissions and Innovations were analyzed.

Nairobi temperatures are typically in the mid-20°Cs, and the building uses this benevolent climate to maximum effect, with natural heating and cooling, abundant natural light, and solar energy. Construction used as many renewable and recycled materials as possible to minimize energy use and hazards to human health, and local materials were selected when available in order to avoid excessive emissions caused by transport. Where local materials were not a viable option, the highest quality materials were imported from elsewhere. These include the frameless curved glass and spider fittings on the stunning, full height, Eastern and Western entrances; the solar glass in the windows that limit the level of solar penetration and insulates the building helping to keep it cool in hot weather and warm in cold weather. The maintenance-free external wall covering; and the dual flush lavatory cisterns cuts water use in bathrooms by greater percentage.

The main entrances are through light and airy atrium spaces. Each block and floor is interconnected by spacious central corridor where goods from the outside can be ferried walkways with views over the exterior landscaped gardens.

All the building windows can be opened and closed so that cross ventilation can take place through the outside into the rooms. Warm air is drawn up from the outside and then escapes beneath the sides of the vaulted roof, maintaining comfortable temperatures in the rooms and air circulation throughout the building. The building's room layout not only provides a livable environment, but also assists greatly in airflow and temperature regulation. When residents of the Garden City residential building Phase 1 , who now occupy the building, were consulted they overwhelmingly said they wanted to be able to open their windows to enjoy fresh air, and close them completely in colder weather, thus keeping some control over their rooms environment. Windows can be operated by anyone in the room easily, and are fitted with solar glass to prevent internal heating from sunlight, but to retain heat in colder weather.

Garden City Village residential building phase 1 is a huge improvement on existing facilities. There are better bathrooms, better kitchens, comfortable room temperatures and an outlook on to green space from everywhere in the building. The excellence of the environment will have a massive positive impact on residents' lives as well as good working environment for those who want to work from home. The building was planned to make maximum use of natural light, simultaneously reducing costs and energy consumption, while creating an attractive living and working environment.

4.2.1 Garden City Village Phase 1 South Africa Green Star – Kenya rating

Garden City Village Phase 1 Residential Building was rated using South Africa Green Star -Kenya rating system. It was given a 4-Star Green Star SA-Kenya Multi Unit Residential v1 rating for the 77-apartments with a total of 46 points. The rating system looked at nine categories which are;

management, indoor environmental quality; energy; transport; water; materials; land and ecology; emissions and innovation. The results were as shown in Figure 10 below.

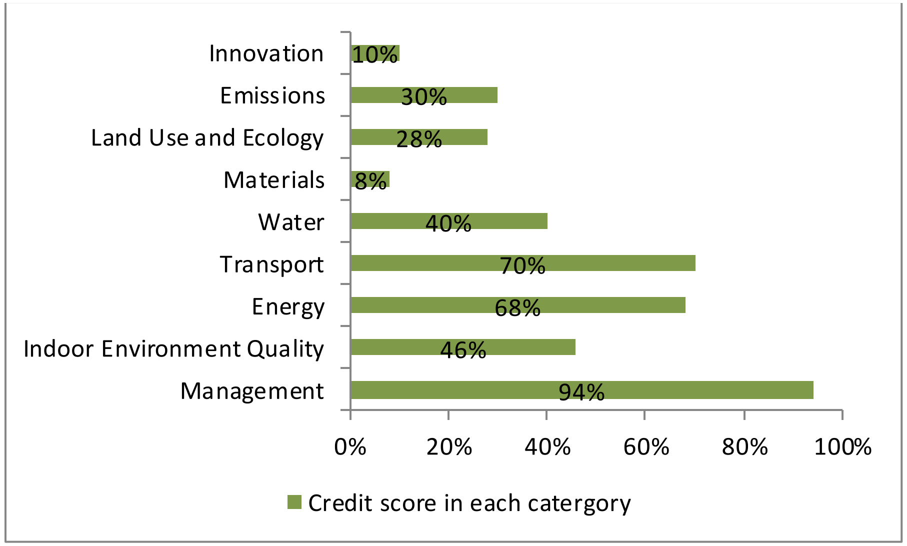


Figure 10: Summary of scores awarded to Garden City Village Phase 1 using Green Star SA -Kenya.
Source: Author, WEB Limited, 2018

The 4-Star Green Star SA-Kenya – Multi Unit Residential v1 rating for the 77-apartment Garden City Village Phase 1 indicates that the building has implemented the best practice of sustainable green building design and construction. On average, the building produces 62% fewer greenhouse gas emissions than average Kenyan buildings, 66% less energy, and 51% less portable, recycles 96% of the construction and demolition waste.

In general, the 4 star rating of the building means that there was a greater environmentally conscious consideration across all key areas, that is, greenhouse gas emissions, energy use, water consumption, and disposal of construction and demolition waste.

4.3 Analysis of Garden City Village Phase 1: Residential Building Using Green Star SA- Kenya.

4.3.1 Management

In this category, the building scored around approximately 94% of all the possible credits. It scored this high amount of credits because it observed the following requirements of management: there was a diversion of almost 94% of the construction waste from landfill; there is provision of building users guide to enable the building's management to achieve its intended environmental performance and all the services of the building are comprehensively commissioned.

4.3.2 Indoor Environmental Quality

The building's rating in this category performed relatively well with an approximate score of 46% of the total number of credits. This was because although there is 100% fresh air supply to the building, there was no single air conditioning unit installed. The building also optimizes artificial lighting levels within its occupied spaces and there is glare control provided to about 67% of the total building's floors by perforated timber screens.

4.3.3 Energy

The building managed to score 68% of the total credits in the category. The building uses an efficient lighting design and solar energy is used to warm bathing water.

4.3.4 Transport

Transport managed to scoop around 70% of the total credits in the category. The building's design provides bicycle racks, lockers and showering facilities for all the tenants in the 77 residential units. There is also an adequate parking space for cars, motorcycles and bicycles provided for the building's tenants. The residential property is excellently linked to the County's public transportation system along the Thika Super High way.

4.3.5 Water

The building scored approximately 40% of the credits allocated to the category. Water conservation features in the buildings included high water efficiency fixtures and fittings in toilets and bathrooms, rain water was harvested for irrigation and other uses and use of low water consuming urinals. The building's low score in this category was largely because there were no black water sewage treatment systems on site, water treatment systems for reuse in the building or cooling control systems in the buildings.

4.3.6 Materials

The building scored just about 8% of the total credits allocated to this category. This relatively low rating was given because a very minimal percentage of the raw materials utilized in the construction of the building were sourced locally and some of the construction practices used were not environmentally friendly. While the building's construction used local stones excavated from Thika quarries, all the finishing materials such as paints, tiles, roofing materials such as metals and cement were imported from outside the country. Further, some of the raw materials used to construct the building were found to be toxic to human health. The construction of the building used PVC pipes extensively. There were no provisions for the recycling of waste in the building. Lastly, sustainable timber was not used in the building.

4.3.7 Land and Ecology

The building scored approximately 28% of the total credits allocated to this category. This was because the building did not produce heavily contaminated waste since it is a residential building. The waste produced is not re-used and is instead deposited in landfills.

4.3.8 Emissions

This category managed to score approximately 30% of the total credits allocated to it. This was because the building produced zero ODP refrigerants and insulates to the atmosphere. On the other hand there is no system for reducing the amount of sewage delivered to the sewerage system. Storm water on the site is not collected or managed properly.

4.3.9 Innovations

The building was awarded 10% of the total credits allocated for this category. These points were awarded due to the building exceeding the Green Star benchmarks for car parking.

The table below illustrates the above ratings in the various categories.

Category Achievements	CREDITS SCORED PER CATEGORY
Management • Comprehensive commissioning of all services. • Diversion of 94% of construction waste from landfill. • Provision of Building Users Guide to enable the building to achieve its intended environmental performance	**94%**
Indoor Environment Quality • 100% fresh air supply. • Glare control provided by perforated timber screens. • Optimization of artificial lighting levels within the occupied space.	**46%**
Energy • Efficient lighting design • Solar energy used to heat bathing water and light the corridors.	**68%**
Transport • Adequate parking spaces, bicycle racks and showering facilities for all the tenants of the 77 apartments. • Excellent links to public transport.	**70%**
Water	

• High water efficient fixtures and fittings in toilets and bathrooms • Rain water is harvesting for irrigation and other uses • Use of low water consuming urinals.	**40%**
Materials • Use of local materials (Building stones excavated from Thika Quarries)	**8%**
Land Use & Ecology • No produce of heavily contaminated waste	**28%**
Emissions • Zero ODP refrigerants and insulates production to the atmosphere	**30%**
Innovation • Car parking exceeding Green Star benchmarks	**10%**
	AGGREGATE SCORE 46% **(4-Star Green Star SA-Kenya-Best Practice)**

Table 11: Summary of Garden City Village Phase 1 Residential Building Achievements.
Source: Author, 2018

4.4 Analysis of Garden City Village Phase 1 residential using the Safari Green Building Index

Testing the Safari Green Building Index (SGBI) rating system on green buildings formed the basis of this study. A checklist was used to rate Garden City Village Phase 1 Residential Buildings in terms of the categories found in the SBGI as follows; prerequisite requirements 0%; the building landscape 5%; passive design strategies 45%; energy efficiency 10%; resource efficiency 30%; noise control and acoustic design 5%; and innovation 5%. This resulted to awarding a level of certification based on the number of points earned out of the possible 100 points while bearing in mind that the building should meet all the prerequisite requirements in the Safari Green Building Index. The results for were as discussed below:

4.4.1 Prerequisite Requirements (0%)

The building met all the prerequisite requirements by complying with the environmental laws of Kenya such as the Environment Management and Coordination Act No 8 of 1999 (EMCA) and the Forest Act Cap 385 Laws of Kenya. Prior to its construction, the building's developer (ACTIS) acquired National Environmental Management Authority (NEMA), Nairobi County Council (NCC) and Nairobi Construction Authority (NCA) permits. Small business occupied the area where the property is located and they had to pave way for the building to be constructed. The building is located along Thika road; 9Km from the Nairobi Central business district and 35.4 Km from Thika Town far away from any forest reserve, wetland, riparian way leave, road reserve or a conservation area.

The building also complies with development ordinances: that is plot ratios and coverage as stipulated by the County Government of Nairobi. The boundaries of the building are clearly defined. It provides universal access for all its users and a building user manual which documents passive and active features in the building

4.4.2 Building Landscape (5%)

Sustainable site planning (2.5%)

Garden City Village Phase 1 Residential Building did not conserve pre-existing buildings and trees and instead it used exotic trees such as the Bamboo which are not adaptable to the area. The building does not impact negatively on the neighborhood; that is there is no pollution noise coming from the building as attested by all tenants of the building. It does not block the view of surrounding buildings .Waste from the building is well disposed of in designated pits. The building disturbed the topography minimally and the design factored in wind direction and speed since it is aligned to the East to West direction. After analyzing this category keenly using the checklist developed by the researcher, it scored 1.87% out of the possible 2.5%.

Figure 11: Garden City Village Phase 1 Residential Building.
Source: Author, 2018

Landscaping and Irrigation (2.5%)

Under this sub-category it was noted that the landscape surrounding the building uses exotic trees such as the Bamboo which require a lot of irrigation since they are not drought tolerant and can wither very fast if not properly irrigated. The water used to irrigate trees is partially harvested rain water while the other half comes from that supplied by the City Council of Nairobi.

The area surrounding the building has very green spaces made up of trees and grass.

Figure 12: Grass covered lawns at Garden City Village
Source: Author

Permeable paving on the landscape is partially provided by the green spaces while walking and cycling is fully provided for through different infrastructures. There is an outdoor living space in each apartment which the tenants can relax whenever they feel like. This sub - category was awarded 1.46% out of the possible 2.5%

Figure 13: Exotic trees used in the building. **Source**: Author, 2018

4.4.3 Passive Design Strategies (45%)

Building Orientation (3%)

This subcategory was awarded 2% of the possible 3% credits because the long axis of the building is not completely along the East –West axis although it has tilted by a very small margin

Space allocation within the building (3%)

This subcategory scored 0% of the possible 3% because all the building services such as; toilets, lobbies, stores, ducts, service rooms, staircases, lifts in the building are not located on the East – West facing facades. They are located in the North – South facing facades.

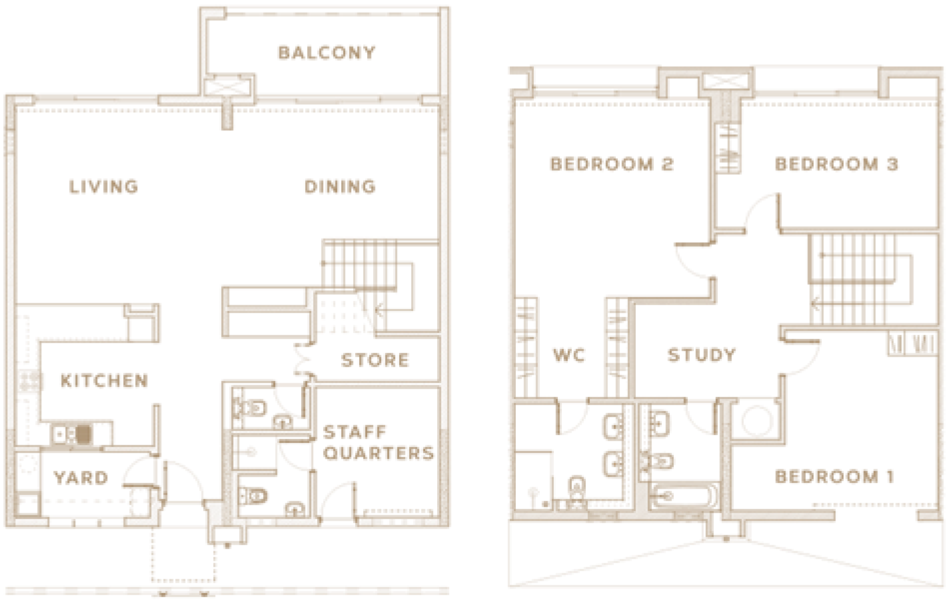


Figure 14: North – South facing facades of the building services (Toilets, lobbies, stores, ducts, service rooms, staircases and lifts)
Source: Author, 2018

Building form and shape (3%)

This category scored all the possible 3% of the credits since maximum light penetration in the building was ensured during the designing phase. The apartments have a ceiling height of 3.1m which is the recommended height for residential buildings. The building form and shape is suitable for the climate of the East African region and more specifically Nairobi.

Openings (5%)

The building has operable timber frame windows placed on the North and south facing ways but its sizes are not appropriate for the East African climate. The window/ wall ration is bigger than 25% since it was recorded at 32% which is way higher above the recommended 25%**.** Additionally the building has fixed ventilation vents made of wire mesh in between the windows allowing free movement of air in the building all the time. This category was awarded 4% out of the total of 5%.

Figure 15: Windows showing wire mesh ventilation for permanent free air movement
Source: Author, 2018

Natural Lighting (5%)

According to Caro Nyambura - the building manager, all spaces within the building are naturally lit during the day. This was confirmed by measuring the depth of the rooms which appeared to be 2 times the windows height which is the recommendable height for any habitable room. The building also performed well on the building depth with windows on opposite facades meeting the recommended building depth of 2 times

(2 x windows height). In the deep rooms there atria, clerestory windows and some rooms have light shelves. This subcategory was awarded 4.55% credits out of the maximum of 5% credits allocated.

Sun shading/ solar control (10%)

Not all all glazed areas in the building, that is North, South, East & West facing facades are sun shaded. From the data collected from the field 6.7% out of the maximum 10% of the floors of the building were sun glazed. They were sun glazed using vertical and horizontal sun-shading elements. According to the building manager, the sun – shading elements were not effective for the design because it was unable to protect the inside of the building from direct sun from 9 AM to 4 PM in the evening.

Thermal Mass (3%)

The building has used high thermal mass for both the walls and the roof. Both were 200mm and 300mm thick respectively protecting the occupants from excessively high temperatures from the outside. This category was awarded the maximum 3% credit since the building had used high thermal mass for both the wall and roof.

Passive heating or passive cooling (2.5%)

The building did not use any passive heating or cooling techniques. The climate of Nairobi does not favour use of such heating or cooling techniques. This Subcategory scored 0% out of the possible 2% of the total credits allocated.

Building Finishes (3%)

Garden City Village Phase 1 Residential Building has used smooth and light colored finishes that reduce solar heat absorption in the building hence enabling the inside of the building to remain cool. All the credits for this subcategory, that is, 3% were awarded since the building adhered to all the building finishing requirements.

Figure 16: The smooth and light coloured finishes of the building
Source: Author, 2018

Natural Ventilation and cooling

The building uses operable windows as a natural ventilation technique to provide cooling. There are no thermal/wind chimneys, wind catchers, ventilation cowls and perforated timber screens but instead the building relies on permanent vents for the cooling purposes. The building also uses cross ventilation for cooling purposes.

Evaporation cooling or rock bed/ground passive cooling techniques are not used in the building but instead it utilizes wind driven natural type of ventilation. Artificial cooling devices such as fans and air conditioning are not used in the building.

Figure 17: Large operable windows on the building.
Source: Author, 2018

4.4.4 Energy Efficiency (10%)

Energy efficient Equipment / appliances / fittings (2.5%)

Not all the equipment / appliances / fittings used in the building are effective in terms of saving energy. The electric equipment installed in the building include cookers, switches/motion detectors and energy saving bulbs. This category was given 1.8% of the total 2.5% credits allocated because some of the equipments fixed consumed a lot of energy.

Renewable Energy (7.5%)

Only solar hot water heating and photovoltaic panels (PV) were used to run heating operations in the building. There was no use of wind, geothermal, micro-hydroelectric, biogas and bio – fueled forms of energy to run the building's operations. Lighting inside the rooms, electric appliances and cooking all used electricity which is a non-renewable form of energy while lighting of the corridors, and water heating used solar energy which is a renewable form energy. This subcategory was awarded 3% of the total 5% credits allocated to it because of the use of solar energy for heating bathing water and lighting the corridors.

Figure 18: The smooth and light coloured external finishes of the building
Source: Author, 2018

4.4.5 Resource Efficiency (30%)

Materials 10%

Choice of Building Materials (External) (7%)

The walling materials used in the building which are mainly blocks from Thika quarries that are locally sourced and appropriate for the climate of Nairobi with no toxic elements on them. The blocks used in the building cannot be re-used again and again hence rendering the building to be a non-sustainable building. Although the roofing materials used in the building are appropriate for the climate of East Africa specifically Nairobi, majority of them such as the metal rods are imported from China. The roofing materials do not contain any toxic elements. They are also not recyclable. The researcher gave this subcategory 5.2% of the total 7% credits awarded

Choice of Building Materials (internal) (3%)

Although the internal texture of the building is smooth with light colour, the materials used are not locally sourced, recyclable and reusable or appropriate for the climate of Nairobi. Most of the materials used such as the paints are imported from outside the country. Due to the importation and non-recyclable nature of the materials used to do the internal finishing, this subcategory scored 0.5% out of the maximum 3% of credits allocated to it.

Water Supply (7%)

Half of the water used to run operations of the building is harvested rain water while the other half is supplied by the City Council of Nairobi. The harvested rain water is used for cleaning, flushing toilets and watering plants. Since the building lacks a treating plant for the rain water, it depends on treated water from the City Council of Nairobi. Water efficient appliances such as water taps, water tanks are incorporated in the building to avoid water wastage. This building scored 3.5% of the total 7% of the credits allocated.

Storm Water Drainage System (3%)

Water from the building naturally soaks into the ground through the green spaces provided. There are no soak ways/ permeable paving to mitigate surface runoff where possible. The researcher therefore allocated a score of 1.5% in this category.

4.4.6 Waste Management (10%)

Solid waste management (4%)

Solid waste generated within the building is not sorted out within its premises nor is the biodegradable waste used to produce biogas, the non-biodegradable waste not recycled. Offsite disposal of solid waste is practised whereby the waste is picked by contracted garbage collection lorries and disposed in the general disposing site. The building scored 1% of the possible 4% credits allocated in this subcategory.

Waste Water management (6%)

There were no grey/black water treatment systems within the building. Environmentally friendly toilets, sewage systems and bio-digesters/ reed bed sewage systems/ oxidation ponds were not used in the building. This building scored 0% out of the possible 6% c allocated to this subcategory because it observes none of the recommended waste water management techniques for the climate of East Africa.

4.4.7 Noise Control and Acoustic Design (5%)

50% of the occupants of the building acknowledged that the building had the recommended ambient sound levels while the other 50% said that the building did not incorporate noise control and good acoustics design since they could sometimes hear noises coming from the adjacent rooms. This building was awarded 2.5% of the total 5% credits allocated to this sub-category.

4.4.8 Innovation (5%)

The building does not use any of the sustainable design innovations such as solar control, natural ventilation, energy efficiency, Resource efficiency and noise control and acoustics. It uses the normal technology which has been in use for a very long time. The building scored 0% credits out of the 5% credits allocated to this category

The table below indicates the SGBI rating scores discussed above.

STRATEGIES	GENERAL DESCRIPTION / RECOMMENDATIONS			COMMENTS	CREDITS AWARDED
1. THE BUILDING LANDSCAPE (5%)					
1. Sustainable site planning (2.5%)	a) Use of existing buildings and trees?	Y	N	No	0%
	b) Negative impact to the neighbourhood e.g. glare, block views, pollution: noise, waste disposal etc.	Y	N	No	0.625%
	c) Topography: Disturbance to the topography minimal?	Y	N	Yes	0.625%

	d) Prevailing wind: wind direction and speed?	Y	N	Yes	0.625%
				TOTAL	**1.8%**
2. **Landscaping and Irrigation** (2.5%)	***Landscape with well-chosen native trees and shrubs etc,*** plants that requires minimal irrigation water to reduce potable water consumption. (2.5%)				
	a) Use of indigenous plants	Y	N	No	0%
	b) Use of non potable water including rainwater or recycled water for landscape irrigation.	Y	N	Partially done	0.21%
	c) Provision of Green spaces/ vegetation on site (grass/ trees)			Yes	0.42%
	d) Provision of Permeable paving on site	Y	N	Partially done	0.21%
	e) Presence of outdoor living spaces	Y	N	Partially done	0.21%
	f) Provision of infrastructure for walking and cycling	Y	N	Yes	0.42%
				TOTAL	**1.4%**
2. PASSIVE DESIGN STRATEGIES (45%)					
SOLAR CONTROL: (37.5%)					
3. Building orientation (3%)	***Design your buildings such that the long axis is along the East-West axis***				
	a) Is the building's *long axis in an East-West orientation?*	Y	N	Partially done	2%
				TOTAL	**2%**
4.Space allocation within the building (3%)	***Locate building services (e.g. toilets, staircases, lifts, lobbies, stores, ducts, service rooms etc) on the East and West facing facades.***				
	a) Are the building's services located on the East and West facing facades?	Y	N	No	0%
5.Building form and shape (3%)	d) Is the building form and shape appropriate for the climate?	Y	N	Yes	3%

				TOTAL	**3%**
6.Openings (5%)	***7.1 Place window openings on the North and South facing wall***				
	a) Are window openings placed on the North and South facing walls?	Y 1.5%	N	Yes	1.5%
	b) Provision for permanent ventilation	Y 1%	N	Yes	1.5 %
	c) Type of windows: For tropical climates operable windows or louvred, with mashrubiya screen etc are advantageous instead of fixed glazed windows.	Y 1%	N	Operable windows	1%
	b) Are the window sizes appropriate for the climate	Y 1%	N	No	0%
				TOTAL	**4%**
7. Natural lighting (5%)	***All spaces should be naturally lit during daytime***				
	a) Depth of habitable rooms: *Recommended depth of room = 2 x window height*			Adhered to	1.25%
	Building depth: *With windows on opposite facades, recommended building depth = 2 x (2 x window height)*			Adhered to	1.65%
	Presence of atria, clerestory windows or light shelves in deep rooms:	Y	N	Y	1.65%
				TOTAL	**4.55%**
8. Sun shading/solar control (10%)	Does the building design sun-shade all glazed surfaces during daytime from 9:00AM to 4:00PM?	Y 5%	N	Partially	6.7%
	Types of sun-shading used				
	Are the sun-shading elements effective for the design	Y	N	No	0%
				TOTAL	**6.7%**
9. Thermal mass	a) Has the building used high thermal mass on walls?	Y	N	Yes	1.5%

	b) Wall thickness:			200mm	
	c) Has the building used high thermal mass on the roof?	Y	N	Yes	1.5%
	d) Roof thickness:			300mm	
				TOTAL	**3%**
10. Passive Heating or Passive cooling (2.5%)	a) Have passive heating or cooling techniques/ measures been included?	Y	N	No	0%
	b) Type of passive heating or cooling measures included			No	0%
				TOTAL	**0%**
11. Building finishes (3%)	***Use external finishes that are smooth and light coloured to reduce solar heat absorption.***				
	a) Has the building used smooth finishes?	Y 0.5%	N	Yes	0.5%
	b) Has the building used light coloured finishes?	Y 2.5%	N	Yes	2.5%
				TOTAL	**3%**
3. NATURAL VENTILATION (7.5%)					
12. Natural ventilation and cooling (7.5%)	a) Are natural ventilation systems included in the building? e.g. i. Presence of permanent vents e.t.c ii. Are there operable windows/ thermal chimneys/ wind chimneys or wind catchers/ ventilation cowls/ roof vents etc.?	Y 5%	N	Yes No thermal chimneys/ wind chimneys or wind catchers/ ventilation cowls/ roof vents	2.475%
	c) Provision of cross-ventilation	Y 2.5%	N	Not fully	1.75%
	d) Type of natural ventilation	Wind driven	Stack driven	Wind driven	
	e) Other passive cooling strategies employed: high thermal mass/green roofs/ vegetation etc			None	0%

	f) Presence of artificial cooling devices (Fans/ Air Conditioning) in special cases e.g. data centers, equipment control rooms etc	Y	N	No	0%
				TOTAL	**4.22%**
4. ENERGY EFFICIENCY (10%)					
13. Energy efficient Equipment / appliances / fittings (2.5%)	***Use of energy saving* equipment / appliances / fittings *is recommended***				
	b)Are energy saving equipment / appliances / fittings used in the building?	Y 2.5%	N	Partially	1.8%
14. Renewable Energy (7.5%)	***Use of renewable energy to power building operations is recommended. Several strategies could be employed:***				
	i. Solar hot water heating	Y	N	Award 1.5 % (POINTS) for every 20% of the building operations powered by renewable energy	Only corridor lighting and water heating used renewable source of energy, that is, Solar energy Each was awarded 1.5% of the total 7.5% credits	1.5%
	ii. Photovoltaic panels (PV)	Y	N			1.5%
	iii. Wind energy	Y	N			0%
	iv. Geothermal	Y	N			0%
	v. Micro Hydro-electric	Y	N			0%
	vi. Biogas	Y	N			0%
	vii. Bio-fuels	Y	N			
					TOTAL	**4.8%**
5. RESOURCE EFFICIENCY (30%)					
MATERIALS: (10%)					
15. Choice of building materials (External) (7%)	**Walls**	Type of walling materials used			
		Are the materials locally sourced?	Y 2%	N	Yes	2%
		Are the materials appropriate for the climate?	Y 1%	N	Yes	1%

		Do the walling materials contain toxic elements	Y	N 0.5%	No	0.5%
		Are the walling materials recyclable/reusable materials	Y 0.5%	N	Yes	0.5%
	Roof	Type of roofing materials used				
		Are the roofing materials locally sourced?	Y 1%	N	No	0%
		Are the roofing materials appropriate for the climate?	Y 1%	N	Yes	1%
		Does the roof contain toxic elements	Y	N 0.5%	No	0.5%
		Are the roofing materials recyclable/reusable materials	Y 0.5%	N	No	0%
					TOTAL	**5.5%**
16. Choice of Building Materials (internal) (3%)	**Internal finishes**	Type of internal finishes used				
		Are the finishes locally sourced?	Y 1%	N	No	0%
		Are the finishes appropriate for the climate?	Y	N	No	0%
		Are the finishes recyclable and reusable?	Y	N	No	0%
		Colours used on surfaces (Light, Dark)	L 0.5%	D	Light	0.5%

		Textures used on surface (Smooth, Rough)	S	R		
	Indoor air pollutants	Minimise airborne contaminants, from the building interiors in order to promote a healthy indoor environment by using finishes without toxic elements.				
		Use of low volatile organic compounds (VOC) paints certified by approved local certification body.	Y 0.5%	N	Yes	0.5%
		Use of environmentally friendly adhesives certified by approved local certification body	Y 0.5%	N	No	0%
					TOTAL	**1%**
	Refrigerants and cleansing agents	Use of zero Ozone Depleting Potential (ODP) products	Y 0.5%	N	Yes	0.5%
					TOTAL	**0.5%**
6. WATER SUPPLY AND DRAINAGE (10%)						
17. Water supply (7%)	a) Incorporation of rainwater harvesting in the project		Y 5.0%	N	Partially	2.5%
	b) Incorporation of water efficient appliances in the project		Y 2.0%	N	Partially	1%
					TOTAL	**3.5%**
7. WASTE MANAGEMENT (10%)						

19. Solid waste management (4%)	a) Promotion of on-site waste sorting	Y	N	Yes	0.75%
	b) Collection of waste by companies that recycle waste	Y	N	No	0%
	c) Production of biogas from biodegradable waste, where applicable	Y	N	No	0%
	d) Offsite disposal of solid waste	Y	N	No	0%
				TOTAL	**0.75%**
20. Waste water management (6%)	a) Use of grey water treatment system	Y	N	No	0%
	b) Presence of black water treatment system	Y	N	No	0%
	c) Type of black water treatment plant or system i.e. Environmentally friendly toilets, sewage systems and bio-digesters/ reed bed sewage systems/ oxidation ponds			No	0%
				TOTAL	**0%**
8. NOISE CONTROL & ACOUSTICS DESIGN (5%)					
19. Noise Control & Acoustics (5%)	Noise Level: Occupied spaces in buildings should be designed with good ambient sound levels i.e. Recommended ambient sound level.				
	Does the project incorporate Noise control and good acoustics design	Y	N	Partially	2.5%
				TOTAL	**2.5%**
9. INNOVATION (5%)					
22. Sustainable design innovations (1% each)	***Use of cutting edge Sustainable design innovations should be encouraged and promoted***				
	Does the project use any sustainable design innovations	Y	N	No	0%
	List of innovations used in the project which promote sustainable design: i. Solar Control			None	0%

	ii. Natural Ventilation iii. Energy Efficiency iv. Resource Efficiency v. Noise Control & Acoustics			
			TOTAL	**0%**
TOTAL CREDITS SCORED				**52.55** **Class D** **(Very weak green building)**

Table 12: Credit distribution for Garden City Village Phase 1 Residential Building using Safari Green Building Index
Source: Author, 2018

4.5 University of Nairobi Towers

University of Nairobi Towers was designed by lead architects Waweru and Associates and constructed by China Wu Yi Company PLC within a period of 3 years starting from June 2013 to the time the building was officially handed over to the University Management in November 2016. The building was constructed to pave the way in ecologically sustainable design in the university's Main Campus and assert and affirm the position of the University of Nairobi as the leader of architectural thought, innovation and the provision of environmentally friendly-solutions. The building is a key Vision 2030 University project and is currently occupied and in use.

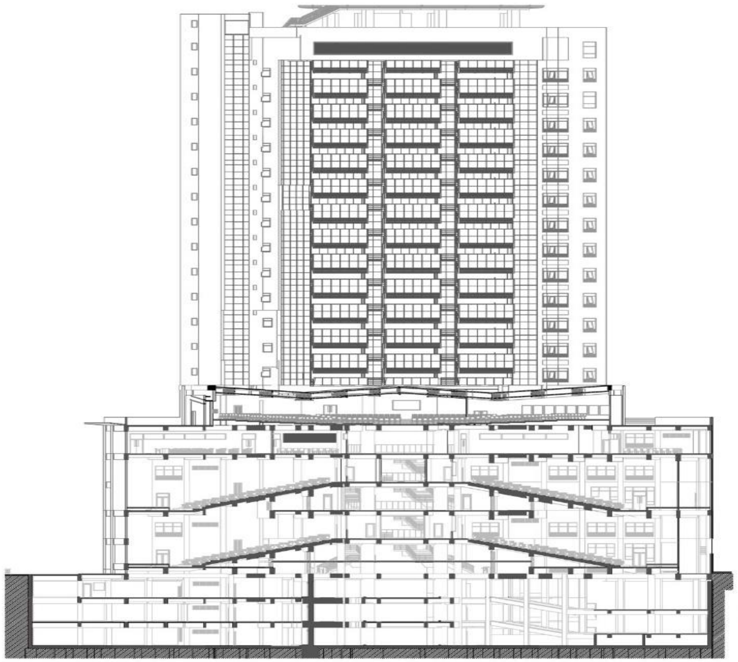


Figure 19: University of Nairobi Towers Building
Source: Author, 2018

The tower is 89 meters high with a capacity of holding 3,500 students at any given time. The building has some obvious features of green buildings such as the water recycling system, the use of solar energy, and a 24 hour security surveillance system. The 22 storey building has a helipad which has been Gazetted as a Class D Aerodrome. It also has a state of the art ICT centre and firefighting equipment.

According to the architect, Gathecha Waweru (2013), The University of Nairobi Towers, is a *"...bold, innovative, sustainable building, which draws from the University's Great Court's strong architectural character, fits into Nairobi's urban context, harnesses its tropical location to design advantage as it unapologetically explores, formal, material and technological innovations of the future*."

The North-South oriented tower, and the podium upon which it sits, is conceived as a green building, incorporating natural ventilation, day lighting, room acoustic design and rainwater harvesting. The building's podium was designed to create harmony with the existing scale and character of the Gandhi Memorial Library Building, and the Education Building, and becomes a thoroughfare through which the Great Court will be accessed.

4.6 Analysis of University of Nairobi Towers Using Green Star SA - Kenya (35.7%)

4.6.1 Management

This tower scored approximately 61.5% of all the possible credits allocated to it. It scored this high amount of credits because it observed the following requirements of management; there is provision of systems information to users, there is monitoring of energy and water use, there is provision of building users guide enable the building to achieve its intended environmental performance and all the services of the building are comprehensively commissioned.

4.6.2 Indoor Environmental Quality

This category performed relatively well with an approximate score of 60% of the total number of credits in the category. This was because although there is 100% fresh air supply, there are no air conditioning units installed.

Figure 20: Windows in the University of Nairobi Towers.
Source: Author, 2018

Figure 21: Large windows for fresh air supply
Source: Author, 2018

The building also optimizes artificial lighting levels within the occupied space of the building and there is glare control provided to the whole building using vertical and horizontal sun-shading elements. Indoor air quality is well provided for through the big windows which have permanent ventilations below them. There are provisions for both natural and artificial lighting, visual and thermal comfort in the building.

Figure 22: Glare Control in the UON towers using vertical and horizontal sun shading elements.
Source: Author, 2018

4.6.3 Lighting

The building managed to score 45% of the total credits in the category as it uses an efficient lighting design and solar energy is used for lighting during the day.

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Figure 23: Lighting in the University of Nairobi Towers.
Source: Author, 2018

4.6.4 Transport

Transport managed to scoop around 40% of the total credits in the category. Though the building has parking lots, it lacks bicycle racks and motorcycle parking spaces. The building is excellently linked to public transportation system since it located along University Way in the Nairobi CBD.

Figure 24: Some of the parking lots used by the users of the UON Towers
Source: Author, 2018

4.6.5 Water

This building scored approximately 50% of the credits allocated to the category. Water conservation features in the building included high water efficient fixtures and fittings in toilets and bathrooms; the use of rain water is harvested for irrigation and other purposes and the use of low water consuming urinals.

There are no black water sewage treatment systems on site, water treatment systems for reuse in the building or cooling control systems in the building.

Figure 25: Irrigation of the lawns at UON Towers
Source: Author, 2018

Figure 26: Some of water saving fixtures in the toilets
Source: Author, 2018

4.6.6 Materials

The UON Towers scored just about 8% of the total credits allocated to this category. The only factor which made the building score 8% on this category is the fact that it used excavated stone blocks from local quarries. All the finishing materials such as paints, tiles, roofing materials such as metals and cement are imported from outside the country and they are not toxic to human health.

Figure 27: Building blocks used to construct UON Towers
Source: Author, 2018

4.6.7 Land and Ecology

The building scored 80% of the total credits allocated to this category. This was because the building did not degrade but restored the natural environments surrounding the building. Buildings and trees which were adjacent to UON Towers were not interfered with and they were conserved. The building does not produce heavily contaminated waste since it is a public building with permanent cleaners. The waste produced is not re-used and instead is deposited in designated landfills.

Figure 28: Existing buildings
Source: Author, 2018

Figure 29: Existing trees
Source: Author, 2018

4.6.8 Emissions

This building managed to score approximately 20% of the total credits allocated to this category. This was because the building produced zero ODP refrigerants and insulates to the atmosphere. On the other hand there is no system for reducing the amount of sewage delivered to the sewerage system. Storm water on the site is not harvested or managed properly.

4.6.9 Innovations

This category was awarded 10% of the total credits allocated for it. These points were awarded due to the project exceeding Green Star benchmarks for car parking.

The table below illustrates these findings.

Category	TOTAL POINTS	POINTS AWARDED	TOTAL PERCENTAGE
Management			
Green Star Accredited Professional	1	0	
Commissioning and Tuning	4	3	
Fit out Information	2	1	
Commitment to Performance	3	2	
Metering and Monitoring	1	1	
Construction Environmental Management	1	1	
Operational Waste	1	0	
TOTAL POINTS		**8**	**61.5%**
Indoor Environment Quality			
Indoor Air Quality	4	3	
Acoustic Comfort	3	1	
Lighting Comfort	3	1	
Visual Comfort	3	1	
Indoor Pollutants	6	5	
Thermal Comfort	2	2	
Quality of Amenities	2	2	

Ergonomics	1	0	
TOTAL POINTS		**15**	**60%**
Energy			
Greenhouse Gas Emissions	20	9	
TOTAL POINTS		**9**	**45%**
Transport			
Sustainable Transport	7	2.8	
TOTAL POINTS		**2.8**	**40%**
Water			
Potable Water	5	2.5	
TOTAL POINTS		**2.5**	**50%**
Materials			
Life Cycle Impacts	19	0	
Responsible Building Materials	2	0	
Sustainable Products	19	4	
Construction and Demolition Waste	3	0	
TOTAL POINTS		**4**	**8%**
Land Use & Ecology			
Sustainable sites	5	4	
TOTAL POINTS		**4**	**80%**
Emissions			
Light Pollution	1	0.6	
Microbial Control	1	0	
Refrigerant Impacts	1	0	

TOTAL POINTS		**0.6**	**20%**
Innovation			
Innovation	10	2	
TOTAL POINTS		**2**	**20%**
AGGREGATE POINTS		**47.9/130**	**AGGREGATE SCORE 36.8% (The building cannot receive the rating)**

Table 13: Summary of University of Nairobi Towers Points Allocation Using Green Star SA- Kenya
Source: Author, 2018

4.7 Analysis of University of Nairobi Towers using the Safari Green Building Index.

This study subjected the University of Nairobi Towers to green building rating using the Safari Green Building Index (SGBI). The building was analyzed in terms of 7 categories provided by the Safari Building Index as follows; prerequisite requirements 0%, this means that the building has to meet all the prerequisite requirements for it to be rated; the building landscape 5%; passive design strategies 45%; energy efficiency 10%; resource efficiency 30%; noise control and acoustic design 5%; and innovation 5%. This analysis resulted to the determination of a certification level based on the number of points earned out of the possible 100 points provided under the SGBI. The results of this analysis are discussed below;

4.7.1 Prerequisite Requirements (0%)

The building met all the prerequisite requirements by complying with the environmental laws of Kenya such as the Environment Management and Coordination Act No 8 of 1999 (EMCA) and the Forest Act Cap 385 Laws of Kenya. Prior to its construction, the building's developer (ACTIS) acquired National Environmental Management Authority (NEMA), Nairobi County Council (NCC) and Nairobi Construction Authority (NCA) permits. The UON Towers are not built on any forest reserve, wetland, riparian way leave, road reserve or a designated conservation area. The building also complies with development ordinances; its plot ratios and coverage are as stipulated by the County Government of Nairobi. The boundaries of the building are clearly defined.

4.7.2 Building Landscape (5%)

Sustainable site planning (2.5%)

The University of Nairobi Towers conserved existing buildings and trees which are adaptable to the area. It does not impact negatively on the neighborhood as there is no pollution noise coming from the building as attested by all tenants of neighboring buildings. It does not block views of surrounding structures. Waste from the building is well disposed off in designated waste pits. The building's topography is minimally disturbed and its design factored in wind direction and speed since it is aligned to the East-West direction.

Figure 30: Library building adjacent to the UON Towers
Source: Author

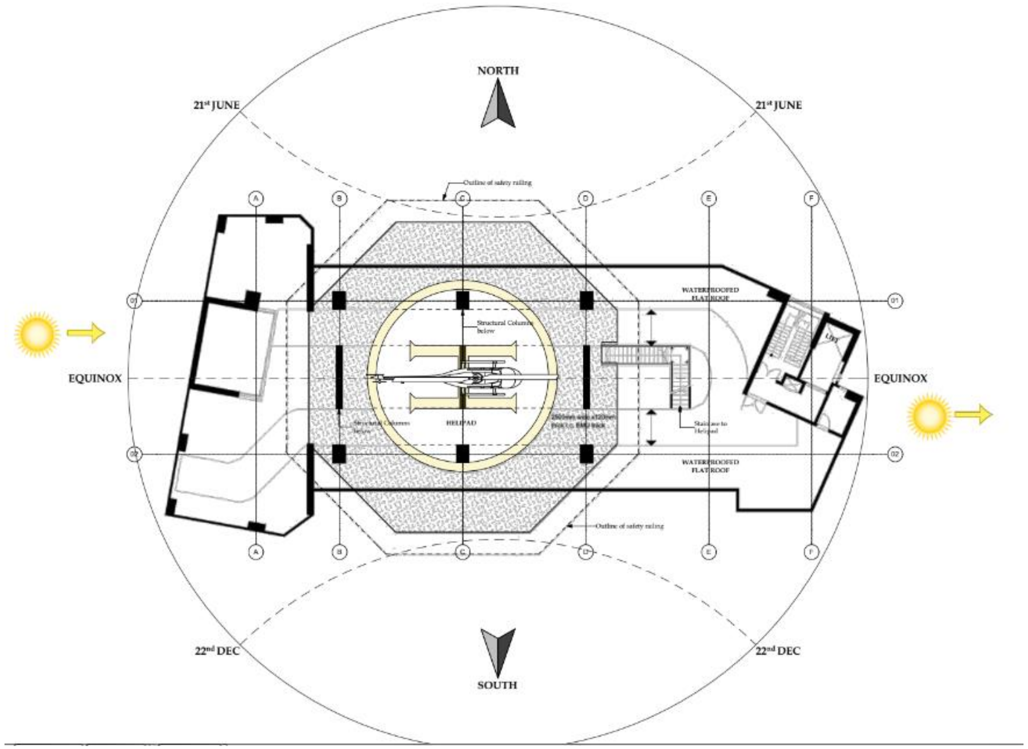


Figure 31: Orientation of the UON Towers
Source: Author

This building was awarded 2% out of the possible 2% in this category.

Landscaping and Irrigation (2.5%)

Under this sub-category it was noted that the landscape surrounding the building uses indigenous trees which do not require irrigation since they are drought tolerant and will not wither in the absence of irrigation.

Figure 32: Environment surrounding the UON Towers
Source: Author, 2018

The area surrounding the building has very green spaces made up of trees and grass. Permeable paving on the landscape is partially provided by the green spaces while walking and cycling paths are fully provided for through different infrastructures. There is an outdoor living space surrounding the building where users of the building can relax whenever they feel like. The building was awarded 2% out of the possible 2.5% available in this subcategory.

Figure 33: Green spaces surrounding UON Towers
Source: Author, 2018

4.7.3 Passive Design Strategies (45%)

Building Orientation (3%)

The building was awarded all the points allocated to this subcategory (3%) because it is aligned in the East – West direction.

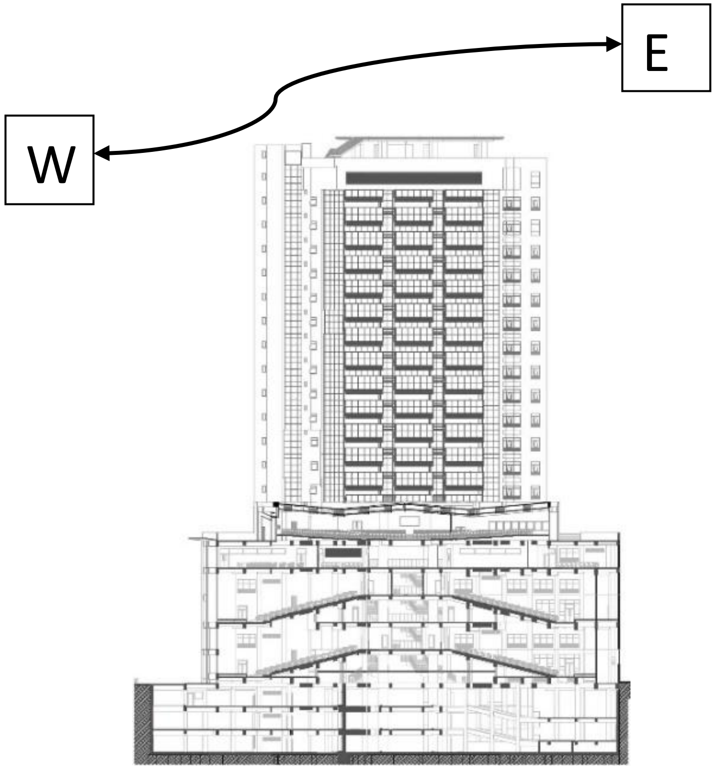


Figure 34: UON Towers Orientation.
Source: Author, 2018

Space allocation within the building (3%)

The building scored 3% of the possible 3% allocated to this category because all the building's service facilities such as; toilets, lobbies, stores, ducts, service rooms, staircases, and lifts in the building are located on the East – West facing facades.

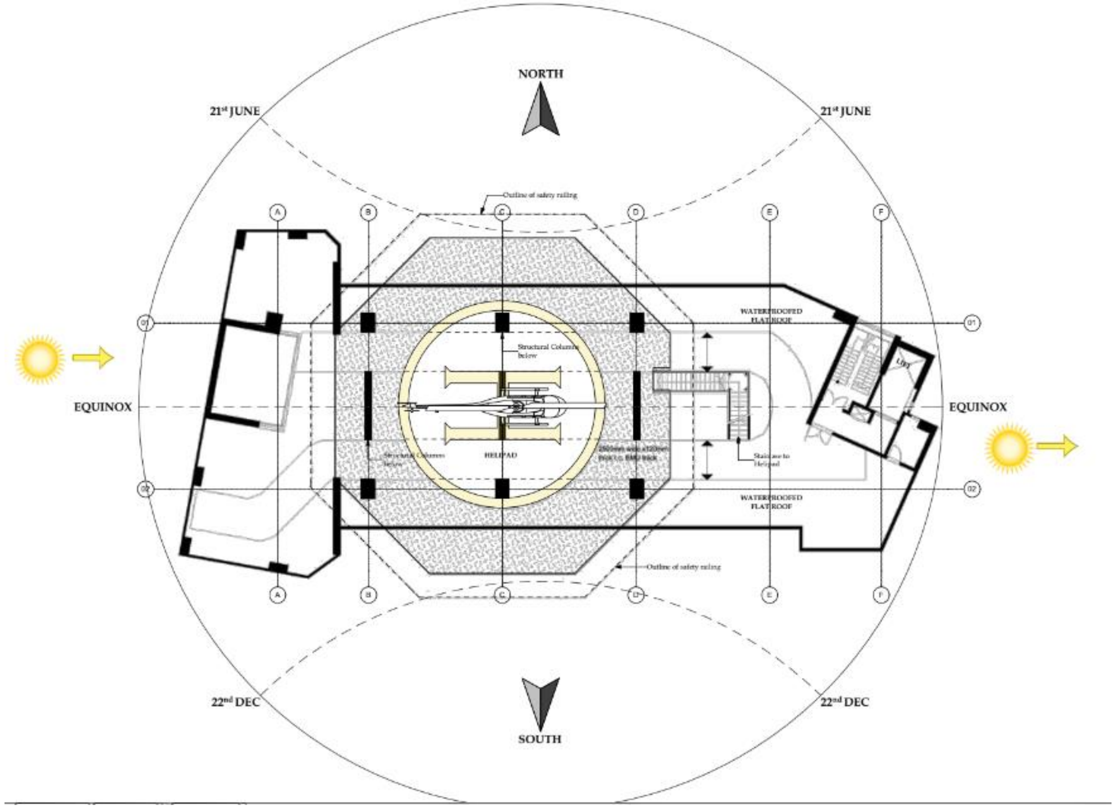


Figure 35: Orientation of UON Towers Services
Source: Author

Building form and shape (3%)

The building scored 1.5% of the possible 3% credits allocated to this subcategory since although maximum light penetration in the building was ensured during the designing phase, the floors of the building do not have the recommended ceiling height of 3.6m. The height of the ceiling is 2.6m which does not comply with recommended height for public/commercial buildings. The building form and shape is good for the climate of East Africa specifically Nairobi.

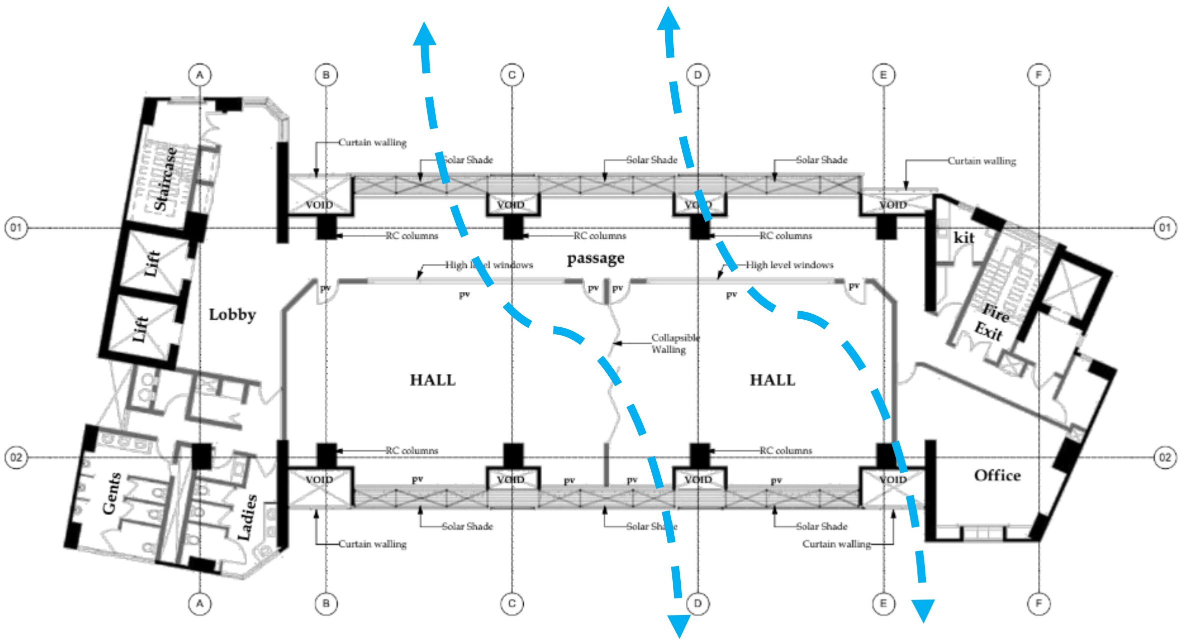


Figure 36: UON Towers Form and Shape
Source: Author, 2018

Openings (5%)

The building has operable timber frame windows placed on its East and West facades but their size is not appropriate for the East African climate. The window/ wall ratio is larger than 25% and was recorded at 40% which is way higher than the recommended 25%. Additionally the building has permanent ventilation vents made of metal blades located just below the windows allowing for free circulation of air in the building at all times. The building was therefore awarded 3% out of the total of 5% allocated to this subcategory.

Figure 37: Operable Timber Frame Windows.
Source: Author, 2018

Natural Lighting (5%)

All spaces within the building are naturally lit during the day. This was confirmed by measuring the depth of the rooms which appeared to be 2 times the windows height which is the recommendable height for any habitable room. The building also performed well on the building depth with windows on opposite facades meeting the recommended building depth of 2 times (2 time's windows height).

This building was awarded 3.5% credits out of the maximum of 5% credits allocated to this subcategory.

Figure 38: Large window opening lighting the building during the day.
Source: Author, 2018

Sun shading/ solar control (10%)

All glazed areas in the building, that is North, South, East & West facing facades are sun shaded. From the data collected from the field all the floors of the building were sun glazed. They were sun glazed using vertical and horizontal sun-shading elements. According to the House Manager, the sun – shading elements were effective for the design because it was able to protect the inside of the building from direct sunlight from 9 Am to 4 Pm in the evening.

The researcher awarded the building with 8% out of the possible 10% allocated to this subcategory.

Figure 39: Glazed windows of the UON Towers
Source: Author, 2018

Thermal Mass (3%)
The building has used high thermal mass for both the walls and the roof.

Figure 40: Thermal mass of both the wall and roof.
Source: Author, 2018

From the measurements taken from the building, both wall and roof thickness was 200mm and 300mm respectively, protecting the occupants from excessive heating from the outside. The building was awarded the maximum 3% credit allocated to this category since it had used high thermal mass for both the wall and roof.

Passive heating or passive cooling (2.5%)

The building did not use any of the passive heating or cooling techniques. The climate of Nairobi requires the use of passive heating and cooling techniques in all buildings. The building was awarded 0% out of the possible 2% of the total credits allocated to this subcategory.

Building Finishes (3%)

The building has used smooth and light coloured finishes that reduce solar heat absorption in the building hence enabling the inside of the building to remain cool. All the credits for this subcategory, that is, 1.5% were awarded since the building adhered to all the building finishing requirements.

Figure 41: Finishing of the building

Source: Author, 2018

Natural Ventilation and cooling (7.5%)

The building uses operable windows as a natural ventilation technique to provide cooling. There are no thermal/wind chimneys, wind catchers, ventilation cowls and perforated timber screens but instead are replaced with permanent vents for the cooling purposes.

Figure 42: Operable windows as a natural ventilation technique to provide cooling.
Source: Author, 2018

The building also utilizes cross ventilation for cooling purposes. Evaporation cooling/rock bed/ground passive cooling techniques are not used in the building but it instead utilizes wind driven natural type of ventilation. Artificial cooling devices such as fans and air conditioning are not used in the building.

The building was awarded 4% out of the total 7.5% allocated to this subcategory.

4.7.4 Energy Efficiency (10%)

Energy efficient Equipment / appliances / fittings (2.5%)

Not all the Equipment / appliances / fittings used in the building are effective in terms of saving energy. The equipment's used in the residential property includes switches, motion detectors and bulbs. This building was given 1% of the total 2.5% credits allocated to this subcategory because some of the equipment's installed consumed a lot of energy.

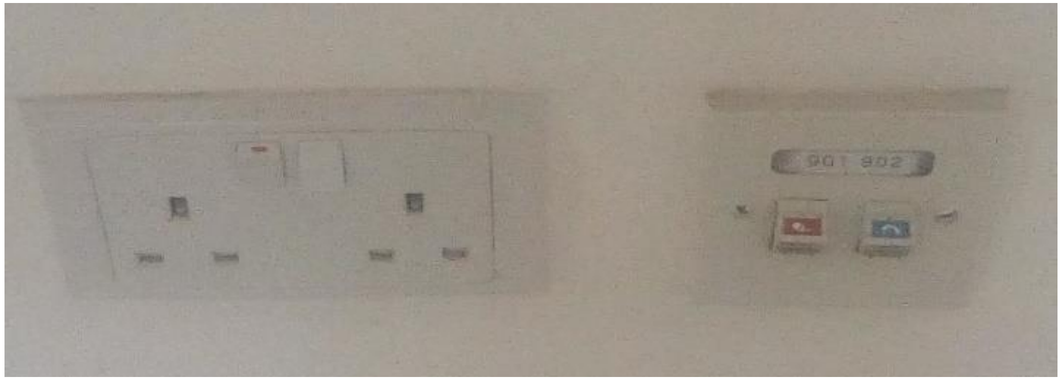


Figure 43: Equipment, appliances and fittings used in the UON Towers
Source: Author, 2018

Renewable Energy (7.5%)

Solar hot water heating and photovoltaic panels (PV) were used to run operations in the building. There was no use of wind, geothermal, micro-hydroelectric, biogas and bio – fuel based forms of energy to run the buildings operations. Lighting inside the rooms, electric appliances and cooking used electricity which is a non-renewable form of energy while lighting of the corridors, and water heating used solar energy which is a renewable form energy. The building was awarded 2% of the total 5% credits allocated to this category because of the use of solar energy for heating bathing water and lighting the corridors.

4.7.5 Resource Efficiency (30%)

Materials 10%

Choice of Building Materials (External) (7%)

The walling materials used in the building which are mainly blocks from Thika quarries are locally sourced and appropriate for the climate of Nairobi with no toxic elements on them. The blocks used in the building cannot be re-used again and again hence becoming non sustainable building. Although the roofing materials used in the building are appropriate for the climate of East Africa specifically Nairobi, they are imported from China especially the metal rods. The roofing materials do not contain any toxic elements. They are also not recyclable. The researcher gave this subcategory 5.2% of the total 7% credits awarded

Choice of Building Materials (internal) (3%)

Although the internal texture of the building is smooth with light colour, the materials used are not; locally sourced, recyclable and reusable and appropriate for the climate of Nairobi. Most of the materials used such as the paints are imported from outside the country. Due to the importation and non-recyclable nature of the materials used to do the internal finishing, the building scored 0.5% out of the maximum 3% of credits allocated to this subcategory.

Figure 44: Internal texture of the UON Towers
Source: Author, 2018

Water Supply (7%)

All the water used to run operations of the building is supplied by the City Council of Nairobi. Since the building doesn't have a treating plant for the water used within, it depends wholly on treated water supplied by the City Council. Water efficient appliances such as water taps are incorporated in the building to avoid water wastage. This building scored 3% of the total 7% of the credits allocated to this subcategory.

Figure 45: Water efficient taps used in the UON Towers
Source: Author, 2018

Storm Water Drainage System (3%)

Water from the building naturally soaks into the ground through the green spaces provided. There are no soak ways/ permeable paving to mitigate surface runoff where possible. The building was awarded 1% of the total 3% allocated to this subcategory.

4.7.6 Waste Management (10%)

Solid waste management (4%)

Solid waste generated within the building is not sorted out within its premises nor is the biodegradable waste used to produce biogas or the non-biodegradable waste recycled. Offsite disposal of solid waste is practised whereby the waste is picked by independent garbage collection agents and disposed in a general disposing site. The building scored 2% of the possible 4% credits allocated to this subcategory.

Figure 46: Containers used for collecting solid waste in UON Towers
Source: Author, 2018

Waste Water management (6%)

There were no grey/black water treatment systems within the building. The building had environmentally friendly toilets and sewage systems. Environmentally friendly bio-digesters/ reed bed sewage systems/ oxidation ponds were not used in the building. This building scored 2% out of the possible 6% credits allocated to this subcategory because it observed none of the recommended waste water management techniques for the climate of East Africa.

Figure 47: Environmentally friendly urinals in the building
Source: Author, 2018

4.7.7 Noise Control and Acoustic Design (5%)

70% of the occupants of the building acknowledged that it had good ambient sound levels and good acoustic design while the other 30% said that the building did not incorporate noise control and good acoustics design since they could hear noises from the adjacent rooms. The building was awarded 2% of the total 5% credits allocated to this subcategory.

4.7.8 Innovation (5%)

The building does not use any of the sustainable design innovations such as solar control, natural ventilation, energy efficiency, resource efficiency and noise control and acoustics. It uses the normal technology which has been in use for a very long time. The building scored 2% credits out of the 5% credits allocated to this category.

The table below highlights the green building rating of the UON Towers as analyzed using the SGBI.

STRATEGIES	GENERAL DESCRIPTION / RECOMMENDATIONS			COMMENTS	CREDITS AWARDED
1. THE BUILDING LANDSCAPE (5%)					
17. Sustainable site planning (2.5%)	a) Use of existing buildings and trees?	Y	N	Yes	0.5%
	b) Negative impact to the neighbourhood e.g. glare, block views, pollution: noise, waste disposal etc.	Y	N	No	0.5%
	c) Topography: Disturbance to the topography minimal?	Y	N	Yes	0.5%
	d) Prevailing wind: wind direction and speed?	Y	N	Yes	0.5%
				TOTAL	**2.0%**
18. Landscaping and Irrigation (2.5%)	***Landscape with well-chosen native trees and shrubs etc,*** plants that requires minimal irrigation water to reduce potable water consumption. (2.5%)				
	a) Use of indigenous plants	Y	N	Yes	0.5%
	b) Use of non potable water including rainwater or recycled water for landscape irrigation.	Y	N	No	0%
	c) Provision of Green spaces/ vegetation on site (grass/ trees)			Yes	0.5%
	d) Provision of Permeable paving on site	Y	N	Partially done	0.05%
	e) Presence of outdoor living spaces	Y	N	Yes	0.5%
	f) Provision of infrastructure for walking and cycling	Y	N	Yes	0.45%
				TOTAL	**2%**
2. PASSIVE DESIGN STRATEGIES (45%)					

SOLAR CONTROL: (37.5%)					
19. Building orientation (3%)	***Design your buildings such that the long axis is along the East-West axis***				
	a) Is the building's *long axis in an East-West orientation?*	Y	N	Yes	3%
				TOTAL	**3%**
20. Space allocation within the building (3%)	***Locate building services (e.g. toilets, staircases, lifts, lobbies, stores, ducts, service rooms etc) on the East and West facing facades.***				
	a) Are the building's services located on the East and West facing facades?	Y	N	Yes	3%
21. Building form and shape (3%)	d) Is the building form and shape appropriate for the climate?	Y	N	Yes	1.5%
				TOTAL	**1.5%**
22. Openings (5%)	***7.1 Place window openings on the North and South facing wall***				
	a) Are window openings placed on the North and South facing walls?	Y 1.5%	N	N	0%
	b) Provision for permanent ventilation	Y 1%	N	Yes	1 %
	c) Type of windows: For tropical climates operable windows or louvred, with mashrubiya screen etc are advantageous instead of fixed glazed windows.	Y 1%	N	Operable windows	1%
	b) Are the window sizes appropriate for the climate	Y 1%	N	Yes	1%
				TOTAL	**3%**
23. Natural lighting (5%)	***All spaces should be naturally lit during daytime***				
	a) Depth of habitable rooms: *Recommended depth of room = 2 x window height*			Adhered to	1.5%

	Building depth: *With windows on opposite facades, recommended building depth = 2 x (2 x window height)*			Adhered to	1.5%
	Presence of atria, clerestory windows or light shelves in deep rooms:	Y	N	Y	0.5%
				TOTAL	**3.5%**
24. Sun shading/solar control (10%)	Does the building design sun-shade all glazed surfaces during daytime from 9:00AM to 4:00PM?	Y 5%	N	Partially	5%
	Types of sun-shading used				
	Are the sun-shading elements effective for the design	Y	N	No	3%
				TOTAL	**8%**
25. Thermal mass	a) Has the building used high thermal mass on walls?	Y	N	Yes	1.5%
	b) Wall thickness:			200mm	
	c) Has the building used high thermal mass on the roof?	Y	N	Yes	1.5%
	d) Roof thickness:			300mm	
				TOTAL	**3%**
26. Passive Heating or Passive cooling (2.5%)	a) Have passive heating or cooling techniques/ measures been included?	Y	N	No	0%
	b) Type of passive heating or cooling measures included			No	0%
				TOTAL	**0%**
27. Building finishes (3%)	***Use external finishes that are smooth and light coloured to reduce solar heat absorption.***				
	a) Has the building used smooth finishes?	Y 0.5%	N	Yes	0.5%
	b) Has the building used light coloured finishes?	Y 2.5%	N	Yes	1%
				TOTAL	**1.5%**
3. NATURAL VENTILATION (7.5%)					

28. Natural ventilation and cooling (7.5%)	a) Are natural ventilation systems included in the building? e.g. i. Presence of permanent vents e.t.c ii. Are there operable windows/ thermal chimneys/ wind chimneys or wind catchers/ ventilation cowls/ roof vents etc.?	Y 5%	N	Yes No thermal chimneys/ wind chimneys or wind catchers/ ventilation cowls/ roof vents	2.25%
	c) Provision of cross-ventilation	Y 2.5%	N	Not fully	1.75%
	d) Type of natural ventilation	Wind driven	Stack driven	Wind driven	
	e) Other passive cooling strategies employed: high thermal mass/green roofs/ vegetation etc			None	0%
	f) Presence of artificial cooling devices (Fans/ Air Conditioning) in special cases e.g. data centers, equipment control rooms etc	Y	N	No	0%
				TOTAL	**4%**

4. ENERGY EFFICIENCY (10%)

29. Energy efficient Equipment / appliances / fittings (2.5%)	***Use of energy saving* equipment / appliances / fittings *is recommended***				
	b)Are energy saving equipment / appliances / fittings used in the building?	Y 2.5%	N	Partially	1%

30. Renewable Energy (7.5%)	***Use of renewable energy to power building operations is recommended. Several strategies could be employed:***					
	i. Solar hot water heating	Y	N	Award 1.5 % (POINTS) for every 20% of the building	Only corridor lighting and water heating used renewable source of	0.5%
	ii. Photovoltaic panels (PV)	Y	N			0.5%
	iii. Wind energy	Y	N			0%
	iv. Geothermal	Y	N			0%

	v. Micro Hydro-electric		Y	N	operations powered by renewable energy	energy, that is, Solar energy Each was awarded 1.5% of the total 7.5% credits	0%
	vi. Biogas		Y	N			0%
	vii. Bio-fuels		Y	N			
						TOTAL	**2%**
5 RESOURCE EFFICIENCY (30%)							
MATERIALS: (10%)							
31. Choice of building materials (External) (7%)	**Walls**	Type of walling materials used					
		Are the materials locally sourced?	Y 2%	N		Yes	2%
		Are the materials appropriate for the climate?	Y 1%	N		Yes	1%
		Do the walling materials contain toxic elements	Y	N 0.5%		No	0.5%
		Are the walling materials recyclable/reusable materials	Y 0.5%	N		No	0%
	Roof	Type of roofing materials used					
		Are the roofing materials locally sourced?	Y 1%	N		Partially	0.2%
		Are the roofing materials appropriate for the climate?	Y 1%	N		Yes	1%
		Does the roof contain toxic elements	Y	N 0.5%		No	0.5%

		Are the roofing materials recyclable/reusable materials	Y 0.5%	N	No	0%
					TOTAL	**5.2%**
32. Choice of Building Materials (internal) (3%)	**Internal finishes**	Type of internal finishes used				
		Are the finishes locally sourced?	Y 1%	N	No	0%
		Are the finishes appropriate for the climate?	Y	N	No	0%
		Are the finishes recyclable and reusable?	Y	N	No	0%
		Colours used on surfaces (Light, Dark)	L 0.5%	D	Light	0.20%
		Textures used on surface (Smooth, Rough)	S	R		
	Indoor air pollutants	Minimise airborne contaminants, from the building interiors in order to promote a healthy indoor environment by using finishes without toxic elements.				
		Use of low volatile organic compounds (VOC) paints certified by approved local certification body.	Y 0.5%	N	Yes	0.30%
		Use of environmentally friendly adhesives certified by approved local certification body	Y 0.5%	N	No	0%

					TOTAL	**0.5%**
	Refrigerants and cleansing agents	Use of zero Ozone Depleting Potential (ODP) products	Y 0.5%	N	No	0%
					TOTAL	**0.5%**
7. WATER SUPPLY AND DRAINAGE (10%)						
17. Water supply (7%)	a) Incorporation of rainwater harvesting in the project		Y 5.0%	N	Partially	2%
	b) Incorporation of water efficient appliances in the project		Y 2.0%	N	Partially	1%
					TOTAL	**3%**
7. WASTE MANAGEMENT (10%)						
19. Solid waste management (4%)	a) Promotion of on-site waste sorting		Y	N	Yes	1%
	b) Collection of waste by companies that recycle waste		Y	N	No	0%
	c) Production of biogas from biodegradable waste, where applicable		Y	N	No	0%
	d) Offsite disposal of solid waste		Y	N	Yes	1%
					TOTAL	**2%**
20. Waste water management (6%)	a) Use of grey water treatment system		Y	N	No	0%
	b) Presence of black water treatment system		Y	N	No	0%
	c) Type of black water treatment plant or system i.e. Environmentally friendly toilets, sewage systems and bio-digesters/ reed bed sewage systems/ oxidation ponds				Yes	2%

				TOTAL	**2%**
8. NOISE CONTROL & ACOUSTICS DESIGN (5%)					
20. Noise Control & Acoustics (5%)	Noise Level: Occupied spaces in buildings should be designed with good ambient sound levels i.e. Recommended ambient sound level.				
	Does the project incorporate Noise control and good acoustics design	Y	N	Partially	2%
				TOTAL	**2%**
9. INNOVATION (5%)					
22. Sustainable design innovations (1% each)	***Use of cutting edge Sustainable design innovations should be encouraged and promoted***				
	Does the project use any sustainable design innovations	Y	N	Y	2%
	List of innovations used in the project which promote sustainable design: i. Solar Control ii. Natural Ventilation iii. Energy Efficiency iv. Resource Efficiency v. Noise Control & Acoustics			None	0%
				TOTAL	**2%**
TOTAL CREDITS SCORED					**50.7** **Class D (Very Weak green building)**

Table 14: Credit distribution for the University of Nairobi Towers using Safari Green Building Index
Source: Author, 2018

4.8 The Strathmore Business School Building (SBS) - Strathmore University

The Strathmore Business School building is a structure within the Strathmore University campus situated in Madaraka Estate approximately 4 km from Nairobi's CBD.

Figure 48: Location of Strathmore University and adjacent roads
Source: Google Maps

The building was designed by Lexicon + Ion Architects and built by Mavji Construction Company Limited. The Civil/ Structural Engineers retained on this project were Apex Consulting Limited.

This building was conceptualized to be a world class training center equipped with adaptable modern facilities and capable of accommodating 800 student executives.

Figure 49: The entrance into the Strathmore Business School Building
Source: (Strathmore Business School, 2012)

The SBS building is the first green business school in Africa and is part of Phase III of Strathmore University's physical development project that begun in October 2008. This 21,000 square meter project comprises of five buildings – the business school building, the management school building, a student center, a dispensary, a power centre and a warehouse. The SBS building was intended to serve the need for world – class executive training in Africa in a building that not only facilitates this but is also environmentally friendly.
The four storied building occupies 4,570 square meters and contains an atrium, an auditorium, a chapel, a dining area, a library and basement area. The atrium is at the heart of the SBS building. This multidimensional space, can be used as an auditorium, graduation court or cinema hall.

It has 12 tiered breakout areas spacious enough to seat 10-20 people, two giant waterfalls and a tensile structured glass roof curtain wall system (Strathmore, 2019).

Figure 50: The Strathmore Business School building
Source: (Strathmore Business School, 2012)

The SBS building was designed to meet the emerging green building standards to the greatest extent possible. The building contains multiple aspects of sustainable architecture specifically orchestrated to suit the purposes of a learning institution. For instance, the building is fitted with indoor air quality systems designed to meet LEED standards with optimum relative air changes controlled using evaporative cooling air units located on the building's roof. Additionally rain water is collected on the roof and stored in an underground tank for use in within the building.

LED lighting within the building is connected directly to photovoltaic solar louvers that minimize energy wastage while at the same time acting as sun shading devices to the East and West facades (Strathmore Business School, 2012).

4.9 Analysis of Strathmore University: Strathmore Business School building using the Green Star SA - Kenya.

4.9.1 Management

The researcher awarded the building with 69.2% of all the possible credits allocated to this category. This score was granted because the researcher observed that the building adhered to the following requirements of management; there is provision of system information to users, there is monitoring of energy and water use within the building, there is provision of building users guide enable the building to achieve its intended environmental performance and all the services of the building are comprehensively commissioned.

4.9.2 Indoor Environmental Quality

This building performed relatively well in this category with an approximate score of 70.8% of the total number of credits. This was because although there is 100% fresh air supply, there are no air conditioning units installed. The building also optimizes artificial lighting levels within the occupied space of the building and there is glare control provided to the whole building using vertical and horizontal sun-shading elements. Indoor air quality is well provided for through the big windows which have permanent ventilations below them. There are provisions for both natural and artificial lighting, visual and thermal comfort in the building.

Figure 51: Main indoor space within the Strathmore Business School building.
Source: Author

4.9.3 Transport

Figure 52: Car parking spaces outside the Strathmore Business School building
Source: Author

The building has car parking lots and motorcycle parking spaces but it does not have bicycle racks. However, building is excellently linked to public transportation system since it located in close proximity to two major roads –Mbagathi Road and Langata Road.

The building managed to scoop 57.1% of the total credits allocated to this category.

4.9.4 Water

The SBS building scored 80% of the credits allocated to this category. Water conservation features in the building included high water efficient fixtures and fittings in toilets and bathrooms and the use of rain water harvested for irrigation, general cleaning and other purposes. The building also employs the use of elaborate passive cooling systems that do not consume energy. There are no black water sewage treatment systems on site, water treatment systems for reuse in the building.

4.9.5 Materials

The Strathmore Business School building scored 30.2% of the total credits allocated to this category. The only factor that was considered when evaluating this category was the fact that the building was constructed using stone blocks excavated from local quarries. All the finishing materials such as paints, tiles, roofing materials and glass planes were imported from outside the country and they are not toxic to human health.

Figure 53: Strathmore Business School building's exterior.
Source: (Strathmore Business School, 2012)

4.9.6 Land and Ecology

The SBS building scored 80% of the total credits allocated to this category. This was because the building did not degrade, but restored the natural environments surrounding the building. The trees which were adjacent to the building were not interfered with during its construction but were conserved. The building does not produce heavily contaminated waste since it is used for educational purposes and has permanent cleaners. The waste produced is not re-used and instead is deposited in designated landfills.

Figure 54: Strathmore Business School building's surrounding landscape.
Source: (Strathmore Business School, 2012)

4.9.7 Emissions

This building managed to score 33.3% of the total credits allocated to this category. This was because the building produced zero ODP refrigerants and insulates into the atmosphere. On the other hand there is no system for reducing the amount of sewage delivered to the sewerage system. Storm water on the site is not harvested or managed properly.

4.9.8 Innovations

The SBS building was awarded 60% of the total credits allocated to this category. These points were awarded due to the use of cutting edge technology in the management of the building to control the use of resources, to monitor the use of energy in the building, to enhance indoor air quality and to limit the building's reliance on artificial lighting. The building also exceeds Green Star benchmarks for car parking.

The table below illustrates these findings

Category	TOTAL POINTS	POINTS AWARDED	TOTAL PERCENTAGE
Management			
Green Star Accredited Professional	1	0	
Commissioning and Tuning	4	3	
Fit out Information	2	1	
Commitment to Performance	3	3	
Metering and Monitoring	1	1	
Construction Environmental Management	1	1	
Operational Waste	1	0	
TOTAL POINTS		**9**	**69.2%**
Indoor Environment Quality			
Indoor Air Quality	4	4	
Acoustic Comfort	3	2	
Lighting Comfort	3	2	
Visual Comfort	3	2	
Indoor Pollutants	6	5	

Thermal Comfort	2	2	
Quality of Amenities	2	2	
Ergonomics	1	0	
TOTAL POINTS		**17**	**70.8%**
Energy			
Greenhouse Gas Emissions	20	12	
TOTAL POINTS		**12**	**60%**
Transport			
Sustainable Transport	7	4	
TOTAL POINTS		**4**	**57.1%**
Water			
Portable Water	5	4	
TOTAL POINTS		**4**	**80%**
Materials			
Life Cycle Impacts	19	0	
Responsible Building Materials	2	1	
Sustainable Products	19	12	
Construction and Demolition Waste	3	0	
TOTAL POINTS		**13**	**30.2%**
Land Use & Ecology			
Sustainable sites	5	4	
TOTAL POINTS		**4**	**80%**
Emissions			

Light Pollution	1	1	
Microbial Control	1	0	
Refrigerant Impacts	1	0	
TOTAL POINTS		**1**	**33.3%**
Innovation			
Innovation	10	8	
TOTAL POINTS		**8**	**80%**
AGGREGATE POINTS		**70/130**	**AGGREGATE SCORE 53.8%**

Table 15: Green building rating of the Strathmore Business School building using Green Star SA- Kenya System
Source: Author

4.10 Analysis of the Strathmore Business School building using the Safari Green Building Index.

This research subjected the SBS building to analysis using the Safari Green Building Index (SGBI) rating system. The checklist used for this purpose assessed the building in terms of seven categories each weighted according to predetermined point based ratings that culminate to 100 points. The categories are: prerequisite requirements 0%; the building landscape 5%; passive design strategies 45%; energy efficiency 10%; resource efficiency 30%; noise control and acoustic design 5%; and innovation 5%.

The results of this analysis are discussed below.

4.10.1 Prerequisite Requirements (0%)

Prior to the construction of the SBS building, the Strathmore University's Board of Trustees acquired all the predevelopment permits and licenses needed. The University was granted the necessary approvals to begin development by the National Environmental Management Authority (NEMA), Nairobi County Council (NCC) and Nairobi Construction Authority (NCA) permits.

Despite neighbouring a large residential area in the Madaraka Estate, the site on which the SBS building was built is very spacious, far away from neighbouring residential and commercial buildings. The building site is not located near any forest reserves or conservation areas. The boundaries of the campus are well defined with well demarcated points of ingress and egress.

4.10.2 Building Landscape (5%)

Sustainable site planning (2.5%)

The SBS building was built on reclaimed land part of which was specifically allocated to them by the Government of Kenya for the purpose of construction of education facilities and part of which was purchased from private individuals. The area on which the building is situated is not agriculturally productive and consists mainly of residential units.

The land surrounding the building site is covered with grass and brush with few pre-existing trees in different stages of maturity. The construction of the building did not negatively impact the environment as no trees were cut down or buildings destroyed to make room for it. The building does not obstruct any views because it is situated well away from the surrounding neighborhood.

Figure 55: Location of Strathmore Business School building.
Source: (Strathmore University, 2015)

The SBS building is situated far away from the neighboring residential units and the busy roads therefore there is little noise pollution incurred by the users of the building or by the people neighboring the campus as a result of the construction of the building.

With these factors in mind, the researcher scored the SBS building 2% out of the possible 2.5% allocated to this category.

Landscaping and Irrigation (2.5%)

The SBS building is surrounded by manicured grass lawns and few indigenous trees carefully landscaped. The landscape requires frequent irrigation especially during the dry months of December to March. The campus uses the rainwater harvested by the building and stored in underground tanks to irrigate the lawns and trees. The area occupied by the campus is covered with lots of grass, trees and paved walkways, cycling paths and parking lots. Permeable paving on the landscape is partially provided by the green spaces.

Figure 56: Strathmore Business School building's manicured lawn.
Source: (Strathmore Business School, 2012)

The researcher awarded the building with 1% out of the possible 2.5% assigned to this sub-category

4.10.3 Passive Design Strategies (45%)

Building Orientation (3%)

The main building mass is oriented in the North- South direction presenting minimal direct solar radiation onto the building façade. The researcher allocated the building with 1% out of the possible 3% due to this sub-category because the long axis is not aligned along the East-West axis.

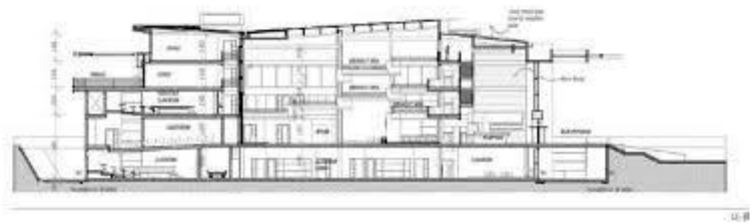


Figure 57: Orientation of Strathmore Business School building.
Source: Author, (Buildesign Kenya , 2015)

Space allocation within the building (3%)

This subcategory scored 0% of the possible 3% because all the building services such as; classrooms, toilets, lobbies, stores, cooling ducts, service rooms and staircases in the building are not located on the East – West facing facades. They are located in the North – South facing facades.

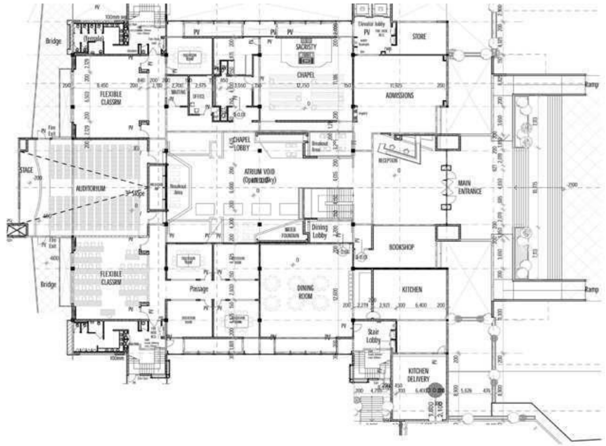


Figure 58: North – South facing facades of the building services (Toilets, lobbies, stores, ducts, service rooms, staircases and lifts)
Source: Author, (Buildesign Kenya , 2015)

Building form and shape (3%)

The SBS building was designed and structured to absorb as much natural light as possible. A large section of the atrium's roof is made of glass which lets in plenty of natural light into that space during the day. Two of the building's walls are made of glass to allow maximum penetration of natural light into the building's interior. The building was also designed to include intelligent space partitioning that allows the transmission of light to reach even to the most interior sections of the SBS building.

Figure 59: Strathmore Business School building - Form
Source: (Lexicon+ion Designs Kenya, 2018)

The building's floors also have light transmitting sections which keep the underground well lit, without relying on electricity. Given the above, the researcher awarded the Strathmore Business School building with 2% of the possible points allocated to this sub-category.

Openings (5%)
The building makes extensive use of natural ventilation through operable windows.

Figure 60: Openings on the Strathmore Business School building.
Source: (Strathmore Business School, 2012)

The design of the SBS building functions to direct air currents into the building to ventilate its interior while at the same time ensuring that external factors such as wind and noise do not interfere with the activities to be conducted within it like learning and research.

Figure 61: Strathmore Business School building's interior partitioning.
Source: (Strathmore Business School, 2012)

The researcher awarded the SBS building 3.5% out of the possible 5% assigned to this subcategory.

Natural Lighting (5%)

The SBS building was designed to make maximum use of natural lighting within its interior and limit the use of artificial lights. The roof section right above the atrium is made of glass to let light into the building. The building's curtain walling has 12mm clear glass that allows for maximum integration of day lighting. The interior spaces of the building were intelligently partitioned to enable natural light to penetrate into the building's depths.

Figure 62: The atrium's glass roofing in the Strathmore Business School building.
Source: (Strathmore Business School, 2012)

Lighting control systems are directly affected by the building's envelope design. The building's management system uses room orientation and time of day to disable the lighting fixtures that are close to the windows when sufficient natural lighting is available. It also disabled all artificial lighting in individual rooms when the motion sensors detect that the room is vacated.

The building was awarded 4.55% points out of the maximum of 5% allocated to this category.

Figure 63: Strathmore Business School building's interior corridors.
Source: (Strathmore Business School, 2012)

Sun shading/ solar control (10%)

The main building mass of the SBS building is oriented in the North- South direction presenting minimal direct solar radiation. The building's windows are set into the wall to provide additional shading by the walls and roof overhang. The Western façade of the building is shaded by a neighboring building while the Eastern side has roof overhangs and inset windows which permit minimal solar radiation into the building. As a result the students are never subjected to the sun's glare during the day.

Figure 64: Roof overhangs on the Strathmore Business School building.
Source: (Strathmore Business School, 2012)

The researcher allocated 9% out of the possible 10% assigned to this category.

Thermal Mass (3%)

The window glass U- value is $6.25X10_{-3}$ $Wm_{2}K_{-1}$ while that of the glass curtain walls is 0.0125 $Wm_{2}K_{-1}$. The building's thermal transmittance through the stone walls and the glass curtain walls provide good thermal storage.

Figure 65: Glass curtain walls on the Strathmore Business School building.
Source: (Strathmore Business School, 2012)

The building's roof is partly covered by a slab structure with a coating of polythene and tar, with a polished aluminum top foil finish to maximize the reflectivity of solar radiation and thus minimize heat gain on the slab.

The SBS building was awarded the maximum 3% points because of these design features.

Passive heating or passive cooling (2.5%)

Part of the SBS building's roof slab structure is coated with polyethene and tar with a polished aluminium foil top finish to maximize reflectivity of solar radiation, thus minimizing heat gain on the slab.

Figure 66: Strathmore Business School building's roof.
Source: (Strathmore Business School, 2012)

The building also has cooling ducts that run all the way down from the fourth floor along a roughened service creating a breeze that cools the building and adds a refreshing quality to the air.

Figure 67: Cooling ducts in the Strathmore Business School building.
Source: (Strathmore Business School, 2012)

These passive cooling techniques are suitable for Nairobi's climate and conserve the energy that would otherwise be used to cool the building. The researcher awarded the building with 1% out of the maximum 2% allocated to this subcategory.

Building Finishes (3%)

The SBS building layout and foundation is constructed using well shaped stones with no exterior finish. Curtain-walling was carried out using 12mm clear glass. The windows are aluminium frame fitted with 6mm clear glass. The building's entire floor is composed of porcelain and ceramic tiles while the interior floors are made of cement with plaster finish. The building's walls are smooth and the classrooms have light colored finishes. The researcher awarded the SBS building with the maximum points of 3% allocated to this subcategory.

Figure 68: Strathmore Business School building’s external finishes.
Source: (Strathmore Business School, 2012)

Figure 69: The smooth interior finishes of the Strathmore Business School building.
Source: Author, (Strathmore Business School, 2012)

Natural Ventilation and cooling (7%)

There are no artificial cooling devices such as fans or air conditioning units installed in the building. Evaporative cooling ducts have been installed throughout the building to further enhance temperature control. These systems are in use only in the basement area which does not have access to the natural ventilation and high indoor air quality enjoyed by the other spaces in the building.

The building has several operable windows that facilitate natural ventilation and cool its interior spaces during hot months. The building utilizes wind driven ventilation on the three floors above ground level. The researcher awarded the SBS building with 6% out of the possible 7% awarded to this category.

Figure 70: Openings on the Strathmore Business School building.
Source: Author, (Strathmore Business School, 2012)

4.10.4 Energy Efficiency (10%)

Energy efficient Equipment / appliances / fittings (2.5%)

The building's electrical needs are served by electricity generated from solar panels installed on its roof, electricity supplied from the national grid and lastly from a back-up generator that is used in event of power cuts. The main source of energy is electricity generated by the solar panels installed on 6 buildings on the campus.

Figure 71: Energy efficient light bulb in the Strathmore Business School building.
Source: Author, (Lexicon+ion Designs Kenya, 2018)

The building's lighting control systems employ the use of technology that disable artificial interior lighting during well-lit daylight hours and when rooms are vacated. The building utilizes energy efficient fluorescent tube lighting with electronic ballast add to the host of other energy saving measures employed in the design. The building also has a full building voltage stabilizer to protect all electronics within it from voltage fluctuations on the national grid. This category was given 2% of the total 2.5% credits allocated due to the extensive energy saving measures undertaken in the building.

Renewable Energy (7.5%)

Some sections of the building are covered with solar panels. These solar panels capture the sun's UV rays and converted from direct current to alternative currents by inverters. During the day, the university's energy needs are served by the approximately 600KW of electricity generated from the 2,400 solar panels installed on the rooftops of six buildings within the campus.

Figure 72: Solar panels on the roof of the Strathmore Business School building.
Source: Author, (Strathmore Business School, 2012)

During the night, the campus relies on power supplied by the national grid. This is mainly because the campus does not have power storage facilities for the solar power generated. This solar power system installed by Quest Works Limited also makes use of technology that allows users to monitor the power generated by each panel on a real time basis. There was no use of wind, geothermal, micro-hydroelectric, biogas and bio – fueled forms of energy to run the building's operations.

Because of the integration of solar power to supply all the electrical needs of the building during the day subcategory was awarded 4% of the total 5% credits allocated to it.

4.10.5 Resource Efficiency (30%)

Materials 10%

Choice of Building Materials (External) (7%)

The building stones used for the construction of the SBS building were locally sourced. They are also not reusable.

Figure 73: Construction of the entrance to the Strathmore Business School building.
Source: (Strathmore Business School, 2012)

Though the timber used for construction was also locally sources, their acquisition did not meet the sustainability standards as the areas from which timber was harvested for construction purposes were not replanted after harvest. The choice of building materials also reflected the careful consideration of the architects of the climatic conditions as by using plenty of glass in the building, the architects ensured that the building would make the most use of the available natural lighting. The roofing materials used in the building do not contain any toxic elements. The researcher gave this subcategory 4% of the total 7% credits awarded

Choice of Building Materials (internal) (3%)

The SBS building was conceptualized to be a state of the art structure employing the use of cutting edge technology while at the same time ensuring that environmentally friendly materials. Achieving this required the building contractors to use of materials not readily available in Kenya

Figure 74: Internal finishes of the Strathmore Business School building.
Source: Author, (Strathmore Business School, 2012)

Even though the building's construction employed the use of sustainable timber instead of the aesthetically preferred types such as mahogany, majority of the materials used to create the internal finishes in the interior of the building were imported from China and are non recyclable. Due to this, the researcher awarded the building 1% out of the maximum 3% allocated to this sub-category.

Water Supply (7%)

An estimated 90% of the water needs for the building are met using the harvested rain water. Rainwater from the building roof is harvested into underground water storage tanks where it is treated before being pumped to the various water taps in the building.

Figure 75: Location of the underground water tank- Strathmore Business School building.
Source: Author, (Strathmore Business School, 2012)

The treated rain water is used in the building's washrooms, to service the fountains, to facilitate cleaning of the building and to irrigate the vegetation in and around the building. The remaining 10% of the building's water needs are met by water supplied to the campus by the City Council of Nairobi.

The building also utilizes water saving taps, tanks and lavatories to minimize water wastage.

Figure 76: Water efficient toilets at the Strathmore Business School building.
Source: Author, (Strathmore Business School, 2012)

This building was therefore given a score of 5% out of the total 7% of the points allocated to this subcategory.

Storm Water Drainage System (3%)

Water from the building naturally soaks into the ground through the green spaces provided. The campus area has sections covered with permeable paving that significantly reduces surface runoff.

The researcher therefore allocated a score of 1% in this subcategory.

Figure 77: Green spaces surrounding the Strathmore Business School building.
Source: Author, (Strathmore Business School, 2012)

4.10.6 Waste Management (10%)

Solid waste management (4%)

The solid waste generated within the building is disposed offsite. Biodegradable waste is not repurposed to produce bio-gas and the non-biodegradable waste is not recycled. There were several bins located within and around the building to reduce littering and enhance efficient waste collection. Some solid waste is separated onsite before disposal offsite. Garbage from the building is collected by contracted independent waste disposal agencies and disposed off in County provided landfills.

The building scored 1% of the 4% points allocated to this category.

Waste Water management (6%)

The design of the building did not take any measures to include grey/black water treatment systems within it. The building site did not include any bio-digesters, red bed sewage systems or oxidation ponds.

Consequently, the building was scored 0% out of the possible 6% allocated to this subcategory.

Noise Control and Acoustic Design (5%)

The design of the SBS building also takes into consideration its purpose as an academic center and goes to great lengths to minimize the impact of external factors that can cause distraction or interfere with teaching activities. Learning centers need to be airy, well lit and serene at the same time. The classrooms were designed with careful attention paid to the distance between the lecturer and the farthest student. The building was also designed to minimize any disruption caused by wind and echoing while keeping sounds balanced and audible.

Figure 78: A training room at the Strathmore Business School building.
Source: Author, (Strathmore Business School, 2012)

The building was awarded 3% of the total 5% credits allocated to this sub-category.

4.10.7 Innovation (5%)

The SBS building has sophisticated building management systems integrated into it to control resource utilization, User defined control – programming was used to define the functioning of the various components such as motion detectors, power cars and lighting control. The building has several features that indicate sustainable design innovation such as lighting control systems, advanced solar power monitoring technology and inbuilt air quality improvement structures.

The researcher therefore awarded the SBS building 4% of the available 5% assigned to this category

The table below indicates the SGBI rating scores discussed above.

STRATEGIES	GENERAL DESCRIPTION / RECOMMENDATIONS			COMMENTS	CREDITS AWARDED
1. THE BUILDING LANDSCAPE (5%)					
1. Sustainable site planning (2.5%)	a) Use of existing buildings and trees?	Y	N	Y	0.5%
	b) Negative impact to the neighbourhood e.g. glare, block views, pollution: noise, waste disposal etc.	Y	N	N	0.5%
	c) Topography: Disturbance to the topography minimal?	Y	N	Y	0.5%
	d) Prevailing wind: wind direction and speed?	Y	N	Y	0.5%
				TOTAL	**2.0%**

2. **Landscaping and Irrigation** (2.5%)	***Landscape with well-chosen native trees and shrubs etc,*** plants that requires minimal irrigation water to reduce potable water consumption. (2.5%)				
	a) Use of indigenous plants	Y	N	Y	0.25%
	b) Use of non potable water including rainwater or recycled water for landscape irrigation.	Y	N	Y	0.25%
	c) Provision of Green spaces/ vegetation on site (grass/ trees)			Y	0.25%
	d) Provision of Permeable paving on site	Y	N	Partially done	0.05%
	e) Presence of outdoor living spaces	Y	N	Y	0.5%
	f) Provision of infrastructure for walking and cycling	Y	N	Y	0.45%
				TOTAL	**1.75%**
2. PASSIVE DESIGN STRATEGIES (45%)					
SOLAR CONTROL: (37.5%)					
3. Building orientation (3%)	***Design your buildings such that the long axis is along the East-West axis***				
	a) Is the building's *long axis in an East-West orientation?*	Y	N	N	0%
				TOTAL	**0%**
4.Space allocation within the building (3%)	***Locate building services (e.g. toilets, staircases, lifts, lobbies, stores, ducts, service rooms etc) on the East and West facing facades.***				
	a) Are the building's services located on the East and West facing facades?	Y	N	N	0%
5.Building form and shape (3%)	d) Is the building form and shape appropriate for the climate?	Y	N	Y	3%
				TOTAL	**3%**
6.Openings (5%)	***7.1 Place window openings on the North and South facing wall***				

	a) Are window openings placed on the North and South facing walls?	Y 1.5%	N	N	0.5%
	b) Provision for permanent ventilation	Y 1%	N	Y	1 %
	c) Type of windows: For tropical climates operable windows or louvred, with mashrubiya screen etc are advantageous instead of fixed glazed windows.	Y 1%	N	Operable windows	1%
	b) Are the window sizes appropriate for the climate	Y 1%	N	Y	1%
				TOTAL	**3.5%**
7. Natural lighting (5%)	***All spaces should be naturally lit during daytime***				
	a) Depth of habitable rooms: *Recommended depth of room = 2 x window height*			Adhered to	1.5%
	Building depth: *With windows on opposite facades, recommended building depth = 2 x (2 x window height)*			Adhered to	1.5%
	Presence of atria, clerestory windows or light shelves in deep rooms:	Y	N	Y	1.55%
				TOTAL	**4.55%**
8. Sun shading/solar control (10%)	Does the building design sun-shade all glazed surfaces during daytime from 9:00AM to 4:00PM?	Y 5%	N	Y	5%
	Types of sun-shading used				
	Are the sun-shading elements effective for the design	Y	N	Y	4%
				TOTAL	**9%**
9. Thermal mass	a) Has the building used high thermal mass on walls?	Y	N	Y	1.5%
	b) Wall thickness:			200mm	
	c) Has the building used high thermal mass on the roof?	Y	N	Y	1.5%

	d) Roof thickness:			300mm	
				TOTAL	**3%**
10. Passive Heating or Passive cooling (2.5%)	a) Have passive heating or cooling techniques/ measures been included?	Y	N	Y	1%
	b) Type of passive heating or cooling measures included				
				TOTAL	**1%**
11. Building finishes (3%)	***Use external finishes that are smooth and light coloured to reduce solar heat absorption.***				
	a) Has the building used smooth finishes?	Y 0.5%	N	Y	0.5%
	b) Has the building used light coloured finishes?	Y 2.5%	N	Y	2.5%
				TOTAL	**3%**
3. NATURAL VENTILATION (7.5%)					
12. Natural ventilation and cooling (7.5%)	a) Are natural ventilation systems included in the building? e.g. i. Presence of permanent vents e.t.c ii. Are there operable windows/ thermal chimneys/ wind chimneys or wind catchers/ ventilation cowls/ roof vents etc.?	Y 5%	N	Y No thermal chimneys/ wind chimneys or wind catchers/ ventilation cowls/ roof vents	2%
	c) Provision of cross-ventilation	Y 2.5%	N	Y	2%
	d) Type of natural ventilation	Wind driven	Stack driven	Wind driven	
	e) Other passive cooling strategies employed: high thermal mass/green roofs/ vegetation etc			Y Green roofs, cooling ducts	1%
	f) Presence of artificial cooling devices (Fans/ Air Conditioning)	Y	N	Y	1%

	in special cases e.g. data centers, equipment control rooms etc					
					TOTAL	**6%**
4. ENERGY EFFICIENCY (10%)						
13. Energy efficient Equipment / appliances / fittings (2.5%)	***Use of energy saving* equipment / appliances / fittings *is recommended***					
	b)Are energy saving equipment / appliances / fittings used in the building?		Y 2.5%	N	Partially	1%
14. Renewable Energy (7.5%)	***Use of renewable energy to power building operations is recommended. Several strategies could be employed:***					
	i. Solar hot water heating		Y	N	Award 1.5 % (POINTS) for every 20% of the building operations powered by renewable energy	All day electricity needs supplied by renewable source of energy, that is, Solar energy Each was awarded 1.5% of the total 7.5% credits	1%
	ii. Photovoltaic panels (PV)		Y	N		1%
	iii. Wind energy		Y	N		0%
	iv. Geothermal		Y	N		0%
	v. Micro Hydro-electric		Y	N		0%
	vi. Biogas		Y	N		0%
	vii. Bio-fuels		Y	N		
					TOTAL	**4%**
RESOURCE EFFICIENCY (30%)						
MATERIALS: (10%)						
15. Choice of building materials (External) (7%)	**Walls**	Type of walling materials used				
		Are the materials locally sourced?	Y 2%	N	Y	1.5%
		Are the materials appropriate for the climate?	Y 1%	N	Y	0.5%
		Do the walling materials contain toxic elements	Y	N 0.5%		0.5%

					N	
		Are the walling materials recyclable/reusable materials	Y 0.5%	N	N	0%
	Roof	Type of roofing materials used				
		Are the roofing materials locally sourced?	Y 1%	N	Partially	0.5%
		Are the roofing materials appropriate for the climate?	Y 1%	N	Y	0.5%
		Does the roof contain toxic elements	Y	N 0.5%	N	0.5%
		Are the roofing materials recyclable/reusable materials	Y 0.5%	N	N	0%
					TOTAL	**4%**
16. Choice of Building Materials (internal) (3%)	**Internal finishes**	Type of internal finishes used				
		Are the finishes locally sourced?	Y 1%	N	N	0%
		Are the finishes appropriate for the climate?	Y	N	Y	0.2%
		Are the finishes recyclable and reusable?	Y	N	N	0%
		Colours used on surfaces (Light, Dark)	L 0.5%	D	Light	0.2%
		Textures used on surface (Smooth, Rough)	S	R		

	Indoor air pollutants	Minimise airborne contaminants, from the building interiors in order to promote a healthy indoor environment by using finishes without toxic elements.				
		Use of low volatile organic compounds (VOC) paints certified by approved local certification body.	Y 0.5%	N	Y	0.3%
		Use of environmentally friendly adhesives certified by approved local certification body	Y 0.5%	N	N	0.1%
					TOTAL	**0.7%**
	Refrigerants and cleansing agents	Use of zero Ozone Depleting Potential (ODP) products	Y 0.5%	N	N	0%
					TOTAL	**0.3%**
8. WATER SUPPLY AND DRAINAGE (10%)						
17. Water supply (7%)	a) Incorporation of rainwater harvesting in the project		Y 5.0%	N	Y	4%
	b) Incorporation of water efficient appliances in the project		Y 2.0%	N	Partially	1%
					TOTAL	**7%**
7. WASTE MANAGEMENT (10%)						
19. Solid waste management (4%)	a) Promotion of on-site waste sorting		Y	N	Y	0.5%
	b) Collection of waste by companies that recycle waste		Y	N	N	0%

	c) Production of biogas from biodegradable waste, where applicable	Y	N	N	0%
	d) Offsite disposal of solid waste	Y	N	Y	0.5%
				TOTAL	**1%**
20. Waste water management (6%)	a) Use of grey water treatment system	Y	N	N	0%
	b) Presence of black water treatment system	Y	N	N	0%
	c) Type of black water treatment plant or system i.e. Environmentally friendly toilets, sewage systems and bio-digesters/ reed bed sewage systems/ oxidation ponds			N	0%
				TOTAL	**0%**
8. NOISE CONTROL & ACOUSTICS DESIGN (5%)					
17. Noise Control & Acoustics (5%)	Noise Level: Occupied spaces in buildings should be designed with good ambient sound levels i.e. Recommended ambient sound level.				
	Does the project incorporate Noise control and good acoustics design	Y	N	Partially	3%
				TOTAL	**3%**
9. INNOVATION (5%)					
22. Sustainable design innovations (1% each)	***Use of cutting edge Sustainable design innovations should be encouraged and promoted***				
	Does the project use any sustainable design innovations	Y	N	Y	4%
	List of innovations used in the project which promote sustainable design: i. Solar Control ii. Natural Ventilation iii. Energy Efficiency iv. Resource Efficiency			Solar Control Natural Ventilation Resource Efficiency Energy Efficiency	0%

	v. Noise Control & Acoustics			
			TOTAL	**4%**
TOTAL CREDITS SCORED				**60.8%** **Class B Green Building**

Table 16: Evaluation of the Strathmore University: Strathmore Business School building using the Safari Green Building Index.
Source: Author, 2018

4.11 Summary of Findings

The following summary of the findings of this study are organized according to the seven aspects of green building design assed by the Safari Green Building Index (SGBI).

4.11.1 Prerequisite requirements

Both the Green Star Sa- Kenya and the Safari Green Building Index rating systems require owners of green buildings to obtain all the necessary government approvals and permits before construction may begin. In the case of green buildings in constructed in Nairobi, these permits and licenses are regulated by the National Environmental Management Authority, the Nairobi County Council and the Nairobi Construction Authority. From the analysis above, all three buildings had met the prerequisite requirements. All the buildings rated in this study had met the prerequisite requirements.

4.11.2 Building landscape

This category of SGBI rating system examines the sustainability of the building site and the effect the construction of the green building has had on the surrounding neighborhood, topography and natural environment. This category is divided into two subcategories namely sustainable site planning & landscaping and irrigation. This category assesses a green building's use of indigenous plants, provision of outdoor infrastructure (walkways, bicycle paths), the use of harvested rainwater for irrigation and any negative impact occasioned to preexisting buildings, trees, surrounding neighborhood and topography.

The table below shows the ratings of the three buildings in the building landscape category of the SGBI.

	Sustainable site Planning (2.5%)	**Landscaping and Irrigation (2.5%)**
Garden City Village Phase 1	1.8%	1.4%
University of Nairobi Towers	2%	2%
Strathmore Business School building	2%	1.75%

Table 17: SGBI Building Landscape ratings
Source: Author

The Green Star SA- Kenya rating system assesses the building landscape in two subcategories. Jointly the maximum number of points allocated to these two categories (6 points) account for 4.6% of the total number of points used in the Green Rating system. The scores assigned to the three buildings are indicated in the table below.

	Garden City Village Phase 1	**University of Nairobi Towers**	**Strathmore Business School building**
Construction Environmental Management (1 point)	1	1	1
Sustainable sites (5 points)	5	4	4

Table 18: Green Star SA- Kenya Building Landscape ratings
Source: Author

The above findings indicate that the SGBI pays greater attention to the landscape on which green buildings are constructed than the Green Star SA- Kenya rating system does. Further, the SGBI is keen to assess the impact the construction of a building has on the surrounding natural environment and to the neighborhood where it is constructed. In this regard, the SGBI is better suited to determine whether or not the construction of a building enhances the sustainable development of an area.

4.11.3 Passive design strategies

The SGBI evaluates a green building's utilization of passive design strategies in 2 main categories these are solar control and natural ventilation 10 subcategories. These subcategories assess the building's orientation, space allocation, shape and form, openings, use of natural lighting, sun control elements, thermal mass, use of passive heating or cooling techniques, building finishes and use of natural ventilation and cooling systems. The table below shows the scores awarded to the three buildings.

	Garden City Village Phase 1	**University of Nairobi Towers**	**Strathmore Business School building**
Solar Control (37.5%)	23.25%	22.5%	27.5%
Natural Ventilation (7.5%)	4.22%	4%	6%

Table 19: SGBI Passive design strategies ratings
Source: Author

The Green Star Rating SA- Kenya system only assesses one passive design strategy and this under a subcategory of thermal mass. The table below illustrates the scores of the three buildings as regards their thermal mass.

	Thermal Comfort (2 points)
Garden City Village Phase 1	2
University of Nairobi Towers	2
Strathmore Business School building	2

Table 20: Green Star SA- Kenya Passive design strategies ratings
Source: Author

Passive design strategies in green building mainly involve the use of green building designs that rely on the building's architecture to minimize energy consumption. These strategies ought to be carefully considered and optimized for interaction with the local microclimate. The SGBI rating system places a greater emphasis on the implementation of passive design strategies in building design and construction than the Green Star rating system. The use of passive design strategies in green building design in Nairobi is ideal given the warm climate of the region and the high energy costs that are prevalent.

Green buildings in Nairobi ought to minimize their dependence on mechanical systems for temperature control and thermal performance. In this regard, the SGBI is better suited for rating green buildings in Nairobi than the Green Star SA- Kenya system.

4.11.4 Energy efficiency

The SGBI assesses the energy efficiency levels of green buildings using two subcategories. These subcategories evaluate a building's use of energy efficient equipment or appliances and the use of renewable energy sources. The table below indicates the scores of the three buildings in this category.

	Garden City Village Phase 1	University of Nairobi Towers	Strathmore Business School building
Energy efficient Equipment/ Appliances (2.5%)	1.8%	1%	1%
Renewable Energy (7.5%)	3%	1%	3%

Table 21: SGBI energy efficiency ratings.
Source: Author

The Green Star SA- Kenya rating system does not evaluate the energy efficiency aspects of green buildings. This is especially concerning for green building practitioners in Nairobi because of the high costs of fossil fuel-based energy sources and electricity. Given that heating, cooling and lighting appliances and systems are all energy intensive, it stands to reason that a suitable green building system would encourage or require the use of renewable sources of energy to serve these appliances or systems or alternatively encourage building owners to use energy efficient appliances or systems.

4.11.5Resource efficiency

The SGBI rates the resource efficiency of green buildings based on 3 main categories. These categories are materials, water supply and drainage and lastly, waste management. These three subcategories are further organized into 6 subcategories. These are choice of external building materials (for walls& roofs), the choice of internal building materials (Internal finishes, indoor air pollutants, use of refrigerants and cleaning agents), water supply and solid waste management**.**

The scores of the three buildings as regards the three main subcategories are indicated in the table below.

	Garden City Village Phase 1	University of Nairobi Towers	Strathmore Business School building
Materials (10%)	7%	6.2%	5%
Water Supply and Drainage (10%)	3.5%	3%	7%
Waste Management (10%)	0.75%	4%	1%

Table 22: SGBI Resource Efficiency ratings
Source: Author

The Green Star SA- Kenya system assesses resource efficiency in four main categories. These are management indoor environment quality, energy, transport and materials. These main categories contain subcategories that evaluate operational waste, indoor air quality, lighting comfort visual comfort, visual comfort indoor pollutants, quality of amenities, ergonomics, green house gas emissions, sustainable transport, life cycle impacts, responsible building materials, sustainable products, disposal of construction and demolition waste, light pollution, microbial control and refrigerant impacts.

The scores allocated to the three buildings as regards the four main categories are indicated in the table below.

	Garden City Village Phase 1	University of Nairobi Towers	Strathmore Business School building
Management (13 points)	12.2	8	9
Indoor Environmental Quality (24 points)	11.04	15	17
Energy (20 points)	13.6	9	12
Transport (7Points)	4.9	2.8	4

Table 23: Green Star SA- Kenya Resource Efficiency ratings
Source: Author

It is clearly evident that the Green Star SA- Kenya rating system pays closer attention to the resources invested in green buildings. In terms of category weightings, the four categories related to resource efficiency in the Green Star rating system account for 49.2% of the total number of points in the rating system. On the contrary, the total weighted credits allocated to the three categories related to resource efficiency in the SGBI account for 30% of the total credits in this rating system. The primary concern for green building architects in designing indoor environments in Nairobi is regulating room temperature and enhancing indoor air quality. These aspects are not adequately addressed by the Green Star SA- Kenya rating system.

4.11.6Noise control and acoustic design

The SGBI assesses the noise levels within a green building and the measures incorporated in the building's design to control noise levels and enhance good acoustics.

The table below shows the scores of each of the three buildings.

	Noise Control &

	Acoustics (5%)
Garden City Village Phase 1	2.5%
University of Nairobi Towers	2%
Strathmore Business School building	3%

Table 24: SGBI Noise Control and Acoustics ratings
Source: Author

The Green Star SA- Kenya rating system only rates a green building's acoustic comfort. The scores of the three green buildings are indicated in the table below.

	Acoustic Comfort (3 points)
Garden City Village Phase 1	3
University of Nairobi Towers	1
Strathmore Business School building	2

Table 25: Green Star Acoustic SA- Kenya Comfort ratings
Source: Author

Noise control and acoustics are integral aspects of both residential and educational buildings. High noise levels would severely hamper the ability of students to concentrate in class or for home owners to rest and relax in their homes. Poor noise control would reduce the utility of educational buildings and residential premises and thus reduce their value. The Green Star SA- Kenya rating system places less emphasis on noise control and good acoustics than the SGBI. For this reason, the SGBI is better suited to rate these three buildings than the Green Star SA- Kenya rating system.

4.11.7Innovation

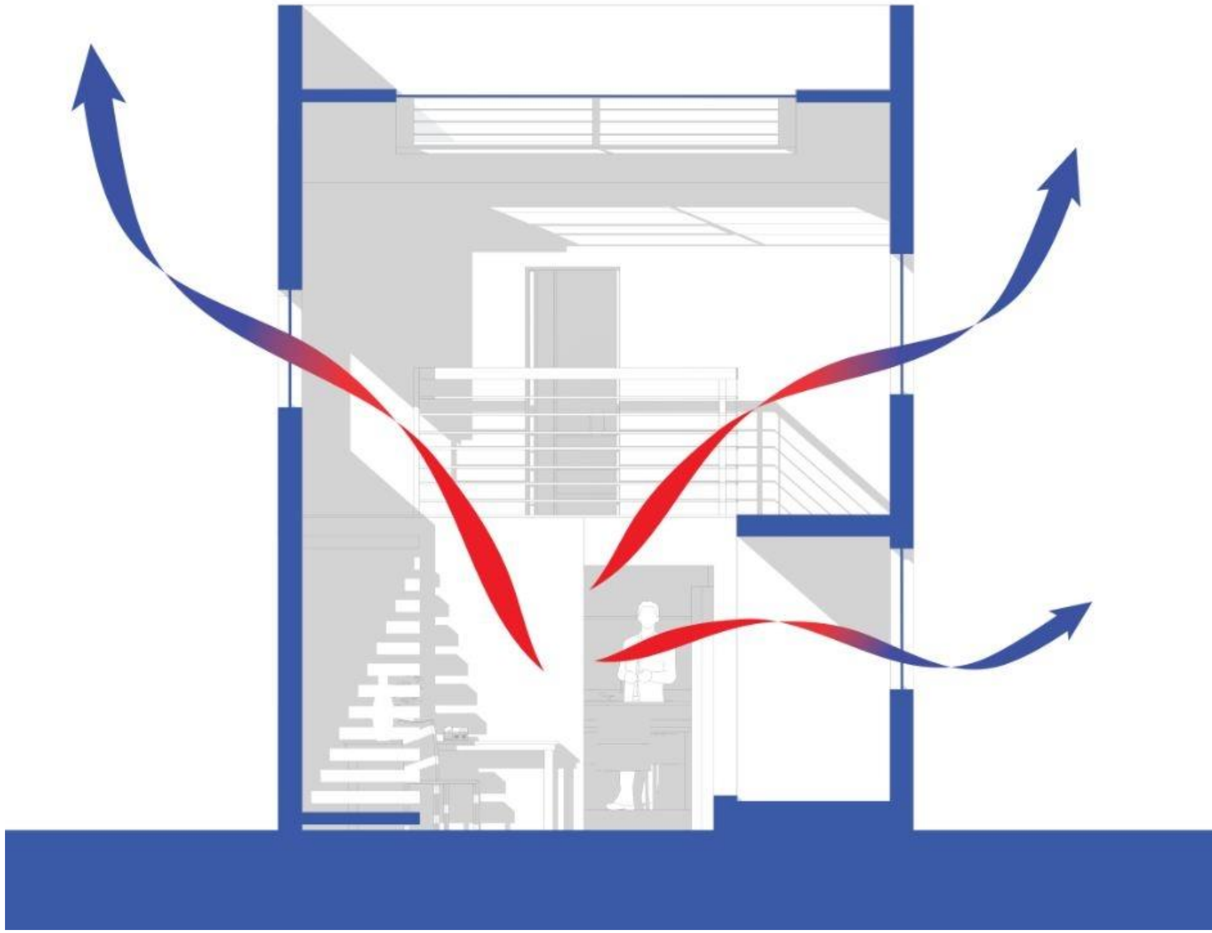
Both the SGBI and the Green Star SA- Kenya systems rate a green building's use of cutting edge sustainable design innovation. This shows the commitment of both these green building systems to encouraging innovation in green building design.

The scores of the three buildings as regards the use of green building techniques are indicated in the table below.

	Innovation SGBI (5%)	**Innovation Green Star SA- Kenya (10 points)**
Garden City Village Phase 1	0%	1
University of Nairobi Towers	0%	2
Strathmore Business School building	4%	8

Table 26: SGBI and Green Star SA- Kenya ratings of Innovation in green building design.
Source: Author

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS



CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The main objectives of this study were:

1. To examine the features of the LEED, Green Star and BREEAM international green building systems to establish their suitability to rate green buildings in Nairobi.
2. To examine the features of the Safari Green Building Index that was developed for adoption in the East Africa region.
3. To determine whether the Safari Green Building Index is better suited to rate sustainable buildings in Nairobi than international green building rating systems.

The study analyzed the four green building systems – BREEAM, LEED, Green Star and SGBI systems, their features and the manner in which green building rating is conducted in each of them. The study also examined the unique climatic conditions of Nairobi, the characteristics of the city's built environment and the adoption of green building systems in the city. The study then assessed the extent to which these rating systems are applicable for use in rating green buildings in Nairobi.

The study then evaluated three green buildings in Nairobi using the Green Star SA- Kenya rating system and the Safari Green Building Index rating system for purposes of determining whether the locally developed SGBI is better suited to rate green buildings in Nairobi. These three green buildings were the Garden City Village Residential buildings Phase 1, the University of Nairobi Towers and the Strathmore Business School building in Strathmore University. After this evaluation, the study found that given Nairobi's environmental and socioeconomic conditions, the SGBI is better suited to rate green buildings in Nairobi County.

5.2 Conclusions

The study found that the three international green rating systems Green Star, LEED and BREEAM were designed to suit the needs of temperate countries. The study found that the SGBI is better suited than international green rating systems because it takes into consideration the climatic, socio-economic and environmental conditions that are specific to Nairobi and the East African region as a whole.

The study therefore concludes that countries in tropical climates need to formulate green building rating tools that specifically designed to suit their climatic conditions while at the same time integrating their unique social infrastructure and economic development.

5.3 Recommendations

The researcher's recommendations relate to the use of both the SGBI and international green building rating systems.

5.3.1: The use of the Safari Green Building Index in Nairobi.

The researcher found that locally developed green building systems are better suited to evaluate green buildings in their territories than international green building systems. Locally developed green building systems take into consideration climatic conditions socio-economic factors, cultural influences and topographical elements in their territories enhancing their accuracy and relevance. The researcher therefore recommends that intensive marketing and outreach initiatives should be conducted to create awareness within the body of green building stakeholders of the various locally developed green building systems such as the SGBI.

Green building practitioners should be encouraged to use locally developed green building systems instead to international ones. Where possible, incentives should be used to encourage more consumers to opt to use locally developed green rating systems.

The researcher also recommends that locally developed green building systems should be reviewed periodically to ensure that innvovations in green building are incorporated into them and further to ensure that they remain relevant to the scientific and technological advancements being made in green building design and construction.

5.3.2: The adoption of international green building rating systems in Nairobi

The researcher recommends that international green building rating systems in use in Nairobi such as BREEAM, LEED or Green Star be thoroughly analyzed by green building professionals practicing in Kenya and the East African region as a whole to clearly identify incongruous aspects contained within them.

Thereafter, these global green building rating systems should be subjected to a process of regionalization to identify the existing credits that need to be prioritized to address the specific issues of the East African region. The credit weighting criteria of these international green building rating systems ought to be reconfigured to account for:

- Building configuration in hot humid regions – green building designs need to mitigate the physiological effects of high temperature and humidity.
- Landscaping – Landscaping can influence the ambient temperatures in a building by providing shade from direct sunlight or redirect wind flow into a building enhancing natural ventilation.
- Building materials – Green building systems should consider the effect of building materials on heat flow in and out of a building.
- Water and energy efficiency – Green buildings must encourage the use of energy and water efficient systems and appliances to mitigate the effects of overreliance on unsustainable sources of water and energy.

The researcher further recommends that stakeholders ought to be provided with sufficient information on the different types of international green building systems to enable them to pick the right rating system to suit the needs of their project.

5.4 Areas for Further Study

The study finds that further research needs to be conducted to identify effective approaches that may be employed to positively influence the perception and knowledge of green building technologies in the East Africa region specifically in Nairobi, Kenya.

The study also recommends further research ought to be conducted to identify the effect of green buildings on the Nairobi's natural environmental and its socio-economic fabric.

Lastly, the study recommends that an in-depth analysis be conducted to ascertain the financial benefit green buildings can bring to Kenya as this will inform local manufacturers to include green product lines in their production and reduce the over-reliance of local green building practitioners on imported building materials.

CHAPTER SIX: REFERENCES

Abdel, H., & Khogali, M. (2016). Comparison of Four Global Sustainable Building Rating Systems Carried out With Focus on Hot and Dry Climate, *9*(2). https://doi.org/10.5539/jsd.v9n2p1

Agnes. (2003). Research design and methodology, 51–77. https://doi.org/10.1057/9781137326072.0007

Akadiri, P. O., Chinyio, E. A., & Olomolaiye, P. O. (2012). Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector, 126–152. https://doi.org/10.3390/buildings2020126

Awadh, O. (2017). Sustainability and green building rating systems : LEED , BREEAM , GSAS and Estidama critical analysis. *Journal of Building Engineering*, *11*(August 2016), 25–29. https://doi.org/10.1016/j.jobe.2017.03.010

Bernardi, E., & Carlucci, S. (2017). An Analysis of the Most Adopted Rating Systems for Assessing the Environmental Impact of Buildings, 1–27. https://doi.org/10.3390/su9071226

Brown, B. C. (2004). Theory and Practice of Integral Sustainable Development; PART 1 – Quadrants and the Practitioner. *Sustainable Development*, *1*, 1–39.

Cheng, J. C. P., & Venkataraman, V. (2013). Analysis of the Scope and Trends of Worldwide Green Building Assessment Standards, *5*(5). https://doi.org/10.7763/IJET.2013.V5.617

Driscoll, D. (2011). Introduction to Primary Research: Observations, Surveys, and Interviews. *Writing Spaces: Readings on Writing*, *2*, 153–174. https://doi.org/10.1111/j.1540-5885.2010.00744.x

Ehsan, S. D., Gombak, J., & Lumpur, K. (2013). Green Building assessment tools : Evaluating different tools for green roof system Muhammad Ashraf Fauzi , 1 , a Nurhayati Abdul Malek 2 , b, *1*(11), 1–14.

Elmeligy, D. A., & Mark, G. (2014). Rating Systems Awareness for Green Buildings Applications system, *3*(5), 53–64.

Etto, P., & Ambiente, D. (2013). Developing a Systemic framework for Applying LEED System Managing Energy and Materials Credits Developing a Systemic framework for Applying LEED System Managing Energy and Materials Credits, 2010–2013.

Feltes, V. (2007). No Title, (May).

Fowler, K. M., & Rauch, E. M. (2006). Sustainable Building Rating Systems Summary, (July 2006).

Franzsen. (2002). Property Assessment for Rating Purposes in Southern and East Africa : Present Status and Future Prospects, 1–11.

Gang, X., & Li, Y. (2012). An Overview of Green Building Rating Systems in the World (10), 205–208.

GBCA. (2013). Green Building Council of Australia The Value of Green Star - A Decade of Environmental Benefits, (May).

Goosen, H., & Glory, P. O. R. (2009). GREEN STAR RATING is it Pain or Glory ? is it.

Guetterman, T. C. (2015). Descriptions of Sampling Practices within Five Approaches to Qualitative Research in Education and the Health Sciences. *Forum: Qualitative Social Research*, *16*(2), 1–34.

Hedaoo, M. N., & Khese, S. R. (2016). A Comparative Analysis of Rating Systems in Green Building, 1393–1399.

Jabareen, Y. (2009). Building a Conceptual Framework : Philosophy , Definitions , and Procedure, 49–62.

Karmany. (2016). Evaluation of Green Building Rating Systems for Egypt.

Khaemba, P., & Mutsune, T. (2014a). An Exploration of Potentials to Green Building Adoption in Kenya, *9*(1), 480–489.

Khaemba, P., & Mutsune, T. (2014b). Potential for Green Building Adoption :, *8*(3), 69–76.

Khese, S. R., Hedaoo, M. N., Konnur, B. A., & Green, K. (2016). A Comparative Study of Rating Systems in Green Building, *6890*(5), 134–136.

Kiprotich, L. E. (2016). An evaluation of occupant perception and satisfaction of indoor environment in Leed-certified buildings in Nairobi, Kenya.

Klein, P. G., & Foss, N. J. (2009). *The Unit of Analysis in Entrepreneurship Research: Opportunities or Investments? Working paper*. Columbia, USA.

Kulshreshtha, A. C. (2013). Basic Concepts of Sampling- Brief Review : Sampling Designs Survey Design – Issues involved. *Second RAP Regional Workshop on Building Training Resources for Improving Agricultural & Rural Statistics Sampling Methods for Agricultural Statistics-Review of Current Practices SCI, Tehran, Islamic Republic of Iran 10-17 September 2013*, (September).

Laurent, M. N. (2009). Master thesis, 1–77.

Meiring. (2014a). *Developing a Sustainability Benchmarking System : A Case Study of the Provincial Government Western Cape ' s*. Stellenbosch University.

Meiring, K. (2014b). *Developing a sustainability benchmarking system : A Case Study of the Provincial Government Western Cape ' s*. Stellenbosch University.

Melorose, J., Perroy, R., & Careas, S. (2015). *No Title No Title*. *Statewide Agricultural Land Use Baseline 2015* (Vol. 1). https://doi.org/10.1017/CBO9781107415324.004

Ownby, T. (2013). Critical Visual Methodology: Photographs and Narrative Text as a Visual Autoethnography. *Online Journal of Communication and Media Technologies*, (January), 1–24.

Palinkas, L. A., Horwitz, S. M., Green, C. A., & Wisdom, J. P. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research, *42*(5). https://doi.org/10.1007/s10488-013-0528-y

Pandey. (2015). Impact of Green Building Rating Systems on the Sustainability and Efficacy of Green Buildings Case Analysis of Green Building Index ,.

Park, J., Yoon, J., & Kim, K. (2017). Critical Review of the Material Criteria of Building Sustainability Assessment Tools. https://doi.org/10.3390/su9020186

Rahi, S. (2017). Research Design and Methods : A Systematic Review of Research Paradigms , Sampling Issues and Instruments Development International Journal of Economics &, *6*(2). https://doi.org/10.4172/2162-6359.1000403

Reed, R., Bilos, A., & Wilkinson, S. (2009). International comparison of sus tainable Rating Tools Authors. *JOSRE*, *1*(1), 1–22.

Reed, R., Wilkinson, S., & Bilos, A. (2011). A Comparison of International Sustainable Building Tools – An Update The 17 th Annual Pacific Rim Real Estate Society Conference , Gold Coast, (January).

Say, C., Wood, A., Buildings, T., Habitat, U., & Star, G. (2008). Sustainable rating systems around the world.

Sinha, gupta, K. (2013). Sustainable Development and Green Buildings Održivi razvoj i zelena gradnja, *64*(1), 45–53.

https://doi.org/10.5552/drind.2013.1205

Solomon, J. (2010). A Conceptual Framework of Conceptual Frameworks : Positioning Corporate Financial Reporting and Aris Solomon *, (04).

Stahl, B., Bultitude, K., & Rainey, S. (2012). Methodology Definition and Observation Tools. *Civil Society Organisations in Designing Research Governance*, (June), 1–29.

Starman, A. B. (2013). Adrijana Biba Starman The case study as a type of qualitative research. *Journal of Contemporary Educational Studies*, 28–43.

Svinicki. (2010). A Guidebook On Conceptual Frameworks For Research In Engineering Education.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research and Applications*, *5*, 147–158.

Utara, U. S. (2011). Simple Random Sampling, 8–9. https://doi.org/10.1007/0-387-31075-4_2

Waidyasekara, S., A., G., K., De Silva, L., M., & Rameezdeen, R. (2013). Comparative study of green building rating system: In terms of water efficiency and conservation. *The Second World Construction Symposium*, *9*(506 2).

Yin, R. K. (2006). Case Study Reserach - Design and Methods. *Clinical Research*, *2*, 8–13. https://doi.org/10.1016/j.jada.2010.09.005