AN INTEGRATED ASSESSMENT TOOL FOR THE DEVELOPMENT OF GREEN LOW-COST HOUSES IN ZAMBIA

By

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A thesis submitted to the University of Zambia in fulfilment of the requirements for the Degree of
Doctor of Philosophy in Construction Management

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DECLARATION

I, Mutinta Mwape Sichali, do declare that this thesis is entirely my own except as specified in acknowledgements and that neither the thesis nor the original work contained therein has been submitted to this or any other institution for a higher degree. Publications from this work are attached as Appendix I.

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CERTIFICATE OF APPROVAL

This thesis of Mutinta Mwape Sichali is approved as fulfilling the requirements for the award of the Degree of Doctor of Philosophy in Construction Management at the University of Zambia.

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ABSTRACT

Green building tools (GBTs), used for planning and assessing the impact of structures on the environment, are developed in consonance with user needs. To attain green low-cost houses, consideration of the three arms of sustainability, i.e., environmental, economic, and social factors should be included. The aim of the study was to investigate the knowledge and utilization of GBTs among the professions in the building industry and to explore the experience of the respondents in applying green strategies in their housing projects. The study identified factors associated with the development of green low-cost houses and suitable criteria for assessing them. The results of the study were used to develop a green building planning and assessment tool for low-cost houses. An integration of criteria in selected tools, parameters in the Sustainability Development Goal 11 and the Sustainability Housing Guidelines were incorporated in the tool. The pragmatic paradigm approach was adopted and epistemologically the research was both subjective and objective in nature. This permitted the use of a mixed method design. An exploratory sequential mixed method approach was adopted. The data was collected using a questionnaire survey and interviews. The results of the study revealed that utilization of GBTs was low, and the knowledge of green buildings varied across the study population with architects having the highest knowledge. The factors that were associated with the use of GBTs were years of experience, the cost of assessment, environmental benefits, lack of technical knowledge, the availability of laws and regulations and tax reduction on green buildings and materials. Environmental criteria were preferred over social or economic factors and these included energy use, materials and health and well-being. The study findings showed that some of the criteria in GBTs were inappropriate for the Zambian building industry, and the expense of certifying structures made the tools unaffordable. The developed tool was made up of 8 components: environmental; social; economic; educational; management; regional priority; community participation and innovation. It had 10 assessment criteria and 16 different planning, design and material solutions integrated into a computer-generated program. The tool was evaluated by experts and recommended for use in updating the current National Housing Policy and architects’ practice manuals. It can also be used for dissemination of green building knowledge to developers, communities, and local planning authorities.

Keywords: Rating Tools, Green Tools, Criteria, Sustainability.

DEDICATION

This thesis is dedicated

To Almighty God
My strength and provider.

My beloved Husband
You stood by me with unfailing love and dedication.

My beloved children
You gave me every reason to go on.

My Mother
You would have been proud of this work.

My father
My role model, always giving me the necessary push.

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LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
BREEAM	Building Research Established Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Building Environmental Efficiency
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen
ECZ	Environmental Council of Zambia
GHG	Green House Gases
GB	Green Building
GBS	Green Building Strategies
GBTs	Green Building Tools
GBCA	Green Building Council of Australia
GBRTS	Green Building Rating Tools
LCA	Life Cycle Assessment
LCCS	Life Cycle Costs
LCC	Lusaka City Council
LCI	Life cycle inventory
MENCNS	Ministry for the Environment, Natural Conservation and Nuclear Safety
MLG	Ministry of Local Government
MLGRD	Ministry of Local Government and Rural Development
UNEP	United Nations Environmental Policies
UNHRP	United Nations Housing Rights Programme
USGBC	United States Green Building Council
WEF	World Economic Forum
SBAT	Sustainable Building Assessment Tool
SA	Sustainability assessment
SD	Sustainable Development
SDGs	Sustainable Development Goals
SHG	Sustainability Housing Guidelines
7^{th} NDP	Seventh National Development Plan

CHAPTER 1 INTRODUCTION

1.1 Background

Housing development and its supportive services remain a challenge for many countries as existing urban housing infrastructure is insufficient to meet housing needs in many economies due to population growth and urbanization (Okoro et al., 2016; Peter and Yang, 2019; Doorn et al., 2019). According to PMRC Housing report, Zambia (2018), there is a shortage of relatively affordable decent housing and inadequate infrastructure for the delivery of social services. This has resulted in the urban development dynamics in the housing sector's inability to keep up with rising urban housing demand (water, sanitation, and waste management). Environmental deterioration, global warming, and the issue of solid, liquid, and toxic waste management have all been brought on by unplanned and rapid urbanization (Makasa, 2010; Ferronato and Torretta, 2019). Negative human activity on the environment includes pollution of water, air and land and this results into uncontrolled/haphazard disposal of various types of solid and liquid wastes (State of The Environment Report Tanzania, 2019).

There is direct and indirect impact of unsustainable housing practices on the environment, and these have been linked to global warming (MLGH, 2016; and Ali et al., 2020). This impact includes flooding, high energy use, and increasing carbon emission resulting into global warming (UNEP, 2020; Lui et al., 2019). Global warming has been felt in many regions with rivers and lakes, which are a source of water and production of hydroelectricity, drying up (Sandanayake, 2022). The environmental challenges have caused many developing countries to look at ways of carrying out housing development in an environmentally responsible way (UNEP, 2020). As stated by former President Ian Khama of Botswana (Esri Magazine 2012 p.1) *'We need to take stock and attach value to our natural resources and ecosystems such that we may include their value in planning and decision-making processes, as well as in our national accounts and balance sheets.'*

Zambia like many other developing countries has been challenged with poor housing and this starts from the physical plans, lack of access to land and poor structures for the urban poor (MLGH, 2016; Simatele et al., 2012; Phiri, 2016; Chitengi, 2020; Chibuye, 2014). Lack of access to land for housing is a major challenge for low-income groups, which constitute 80% of the population, (Habitat for Humanity Report, 2021). The available land lacks essential services such as water and sanitation, and efforts to attain such services have strained ecosystems (Aongola et al., 2009; World Bank, 2020). Many of the people in the informal settlements have poor tenure of land and government serviced land is scarce (Chitengi, 2020; Visagie, J., 2020). Zambia is dealing with a 2.5 million housing deficit and the government has left housing development in the hands of the private sector since 1991 (Makasa, 2010; Phiri, 2016). The challenge of inadequate housing greatly affected the urban poor thus the focus of the study was mostly on lowcost housing. Other forms of housing were not included in the study because that is not where the greatest challenge lies and the negative impact on the environment is greatly felt in low-cost housing (Chitengi, 2020 and PMRC, 2018).

Low-cost housing is an important sector of the housing development because 80% of the Zambian population lives in substandard housing (Phiri, 2016; Makasa, 2010; World Bank, 2020). If low-cost housing is improved, then a big part of the population will be impacted. Because very few people can afford decent housing then sustainable low-cost housing is key to meet this shortage. Currently there is very little development catering for the low-income groups as even the lowest cost house is not affordable for most of the population (NHP, 2020; Harelimana, 2017). The urban poor have been forced to build houses without government support and the result is that houses are being built with materials of high energy intake and impacting the environment very negatively (MLGH, 2016; Kuddus et al., 2020). Sustainable housing construction is not implemented as seen by the type of materials and building technics being used currently. There is no efficient use of energy and sources like charcoal are impacting the environment negatively producing high levels of carbon monoxide (MLGH, 2016).

Due to poor service delivery the use of pit latrines is common with waste seeping into the ground contaminating underground water (UNICEF, 2011; Graham P.J., and Polizzotto, 2013; Lapworth, 2018). According to the Sustainability Housing Guidelines (SHG) (MLGH, 2016 p.10), *'80 percent of existing housing in Zambia can be classified as informal and has limited or no formal services such as electricity, water and sewage.'* The production of building materials in urban settlements requires a significant amount of energy which must be shared among other competing needs. Most of the materials used to build houses in these settlements have a high life cycle cost (Halwatura and Udawattha, 2017). However, housing construction is regarded as an area with a significant opportunity to address climate change and contribute to greening the economy (MLGH, 2016; Kinnunen, et al., 2022; Zhao, et al., 2019).

Buildings have and will continue to, directly and indirectly, impact the environment. Building construction and operations are responsible for 40 percent of the world's total electric energy use, 55 percent of timber harvests, 16 percent of freshwater withdrawal, contributes 35 percent of global carbon dioxide (CO2) emissions and 40 percent of municipal solid waste sent to landfill (WWI, 2014; Sandanayake, 2022; Yan et al., 2020), Oswaldo, 2014; Zarco-Periñán, 2022; and Labaran, et al., 2021). According to the United Nations Environmental Policies (UNEP), the building sector has the most potential for reducing the amount of greenhouse gas (GHG) emissions (carbon dioxide, nitrogen, water vapour, methane, nitrous oxide, and ozone) (UNEP, 2020; Zhong, 2021). The building sector is estimated to be worth ten (10) percent of global GDP (USD 7.5 trillion) and employs 111 million people (UNEP, 2020; Hertwich, 2019). When cautiously planned, greenhouse gas improvement strategies for buildings can encourage the growth of new businesses and jobs and aid other pressing social development goals, such as better housing and the availability of clean energy and water (Bowick, 2014; Ali, 2020).

Building construction activities and buildings themselves can affect the health and comfort of the people that live in them (Forsberg, 2004; Ige, 2019; Dovjak & Kukec, 2019). Poor housing affects the occupant's physical and socio-economic well-being (Woolley, 2016; Grey, 2017). Poorly built and ventilated houses pose a health risk to the occupants; for example, lead-based paints could be carcinogenic and cause cancers (Woolley, 2016; Hashemi et al., 2020; Babaei et al., 2015; Zararsız and A, Oztürk 2020). There is also a high use of wood fuel and is posing a health challenge in settlements and unsustainable harvesting of wood fuel has had a negative effect on the ecosystem, including the depletion of forest stocks and the eventual cause of climate change (UNEP, 2017; Szulecka, 2019; Sassen, 2015). As Gale (2011) has stated, other health challenges may include respiratory problems, headaches, skin irritation, and inflammation of the eyes and ears, known as the Sick Building Syndrome (SBS).

Seeing that sustainable housing has a positive impact on the environment, how can green low-cost houses be attained within the current social and economic set up? And what methods and strategies can be implemented so that issues of sustainability are addressed?

Are there local strategies that could answer the challenge of sustainability in housing development in Zambia?

The Sustainable Development Goals (SDGs) have been developed to address the issues of global warming and climate change. According to the UN it is a road map to achieve peace and prosperity for people and the planet by 2030. Agenda for Sustainable Development (SD) was accepted by all United Nations Member States in 2015. The 17 SDGs are an urgent call to action for all nations to combat poverty by proposing policies that enhance health and education, lessen inequality, promote economic growth, combat climate change, and protect our oceans and forests (UN, 2015). The research in this study addressed green building tools (GBTs) for low-cost housing by applying the 11th SDG. This goal addresses access to safe, affordable, accessible transport systems, sustainable human settlement planning, management, quality air, and accessible green public spaces (UN, 2015). The questions in the adaptation of the SDGs are whether these goals can be applied in achieving sustainable or green houses in Zambia or how far has Zambia gone to meet these goals in low-cost housing development?

Recently, sustainability awareness has increased in developing countries due to high energy consumption, pollution and high carbon footprint (Banani 2011; Al-Shetwi, 2022; Achola, 2022). The environmental impact of buildings, like the waste generated on construction sites and excessive use of limited natural resources (solar energy, water, and construction materials), has long term effects on current users and future generations (WEF, 2021; Santamouris, and Vasilakopoulou, 2021; Tafesse, 2022). Therefore, green, or sustainable buildings (SBs) are designed with low energy utilization, efficient water use, and low utilization of material resources and recycled construction waste (UNEP, 2017; Zhang, 2019). According to MENCNS (2009, p.11), *sustainable construction means responsible supply, operation and maintenance of buildings that meet the needs of their owners and users over their lifespan with minimal unfavorable, environmental impacts, whilst encouraging social-economic, and cultural progress.”*

Rating buildings is one way of assessing the performance in terms of energy use and other resources, thereby reducing the impact of buildings on the environment (Chan, 2021). Through the assessment of buildings, awareness is generated of the effect of harmful materials on occupants. It is also one way the levels of sustainability can be measured or gauged (William et al., 2016; Foggia, 2018). In the study GBTs are those that are used for rating buildings as well as those for planning green buildings (Banani 2011; Anshebo, et al., 2022; Marchi, et al., 2021). The global trend is that GBTs set standards for green measures in construction and reduce the negative impact on the environment (Chan, 2021 Bungau, et al., 2020). Evaluation methods are meant to promote and facilitate greater integration of environmental solutions with cost and other traditional design objectives in SB design, construction, and operation (Mayhoub, 2021; Fenner 2007). Research has proved that structures that have incorporated GBTs have contributed positively to the environment; for instance, GBs use 25 percent less energy, 11 percent less water, 19 percent lower maintenance costs, 34 percent less greenhouse gas emissions and 27 percent of the occupants are generally more satisfied than in conventional buildings (UNEP, 2017; Liu, 2022; Meena, 2022). Studies undertaken in GB have shown that buildings built sustainably can have positive health implications on the occupants, with good ventilation and reduced harmful products in the building structure (Isa et al., 2014; Liu et al., 2022; Al horr, 2016). If assessing buildings have a positive impact in attaining sustainability, then why doesn't rating of buildings take place in Zambia? and if it does, how much of it takes place? and are professionals using green building strategies in their design and construction of buildings?

Most developing countries are lagging in building structures sustainably. It is important to identify the specific challenges that developing countries face in achieving sustainable housing development and find solutions. The study's main aim was to investigate the utilization and knowledge of GBTs among selected professionals from the building industry and explore the most appropriate method and criteria for planning and assessing sustainable, low-cost houses. The research was to find out if knowledge of GB could affect the use of tools. Therefore, comparing the knowledge among the various professionals in the building industry was key. The gap the study addressed was establishing an appropriate tool for assessing low-cost houses in the Zambian building industry. Many scholars have identified factors associated with utilizing GBTs (Darko and Chan, 2017; Windapo, 2014; Tshwane et al., 2014; Lam et al., 2010; Mpakati-Gama et al., 2012). However, the research went beyond pointing out the associated factors but sought to derive solutions from the study respondents on overcoming the negative factors.

There are several factors associated with the slow pace at which GBTs have been implemented in the building industry some of which are environmental, economic, topographical, technical skills, political, and legislative (Song et al., 2021). Others are knowledge, education, cost of GBTs, the government influence and participation, private sector involvement, and available green materials on the market. Knowledge of GB is a significant step towards implementing sustainable buildings practices (Liu, 2022; Huang, 2018). According to the Toronto Green Development Standard (2020), public knowledge about GB is a key factor in raising the demand for sustainable construction. Knowledge of green infrastructure is a problem that cuts across countries and regions (Aje, 2015; Zuniga-Teran, 2019). Although developed countries have a higher number of professionals that use GBTs than underdeveloped nations, many construction industry actors in developed countries are still not using GBTs (Alabi, 2012; Liu, 2022; Bungau, 2020. Geng et al. 2012). Smith et al. (2006) have shown poor perception of GB in their study of construction workers in China and the United States, respectively. The other factor is the cost of using GBTs, which tend to be too expensive for individual GB housing development. A study undertaken in Zambia by Aghimien et al., (2018), found that the fear of higher investment costs was the highest-ranked barrier to sustainable construction and seen also in Häkkinen and Belloni, (2011) and Djokoto et al., (2014). Oguntona et al., (2019) showed that the top factors of GB project implementation included the availability of finance options, a better market for green products/materials, knowledge and training on GB technologies, incentives, and the affordability of GB materials.

Although the GBTs are regional specific common features such as energy, water use, material use sustainable site, transport and pollution are common features in the tool that could help reduce the negative effect of buildings on the environment. This is why the philosophy in the study advocates for a tool that can help reduce these negative effects because most parameters are achievable despite the difference in the climate and environmental conditions. For example, the criteria in LEED, BREEAM or Green Star are the same, but the emphasis differs.

1.2 Statement of the Problem

Zambia is greatly affected by the impact of climate change, particularly in informal settlements that make up 65 percent of the urban poor (MLGH, 2016; Dodman, et al., 2019; Williams et al., 2019). Sustainability challenges are directly linked to many Zambians' economic and social status. The negative effect of the environment has affected the capability of people to meet their basic human needs (MLGH, 2016; Phiri, 2016; Chitengi, 2020). About 68 percent of households depend on forest resources to meet their energy needs (FAO, 2017; Chitengi, 2020; UN, 2015; MLGH, 2016 and Mudenda, et at., 2018). The forests have been depleted, and people travel long distances to get wood. The inhabitants use charcoal as a source of energy and as of 2015 1.5 million tons of charcoal was produced (FAO, 2017). There is insufficient provision of electric energy, and there is a national power deficit is 560 MW (Kaunda, 2013, Nyoni, 2021). Other challenges include land degradation and loss of biodiversity with the felling of rainforests and ecosystem services (FAO, 2017; UN, 2015; Aongola et al., 2009). Butt et al. (2012, p. 642) stated *"The past 20 years have seen a growing realization that the current way of development is unsustainable."* Few materials used in low-cost housing are sustainable materials as most people use concrete blocks which have a high life cycle cost due to cement which is the main component (Phiri and Matipa, 2004). The presence of green materials in the environment can create opportunities to reduce the exploitation of natural resources (Lui, 2022; and Bungau 2022).

In Lusaka, the capital city of Zambia, the estimated average daily demand for water in 2000 was 287 825m^3 per day which was approximately 80 000m^3 per day more than what could be supplied (LCC and ECZ, 2003; De Waele et al., 2004; Museteka & Bäumle, 2009). The water supply in informal settlements is erratic, and the service providers are unable to provide adequate water and sanitation services (Lusaka City Council and ECZ.,2008; Mudenda, et at., 2018 and UNICEF, 2011). The urban poor in Zambia is also grappling with uncontrolled solid waste, which lies uncollected in the streets, with only 20 percent of urban solid waste being disposed of (Al-Khatib et al., 2015; Hilburn, 2015; Zulu, 2019). It is a significant public health issue that affects people all over the world and results in deteriorating environmental health conditions and fuels the spread of disease (Zulu, 2019). If waste could be reduced sustainably from the source, this would reduce the cost of garbage collection and clearing of waste at the dumpsite.

The challenge that developing countries like Zambia face is the absence of local tools and even access to globally recognized ones (Aghimien et al., 2018; Zulu et al., 2022). When dealing with poor economies where few buildings exceed 10,000 square meters, adopting foreign-based tools like Leadership in Energy and Environmental Design (LEED) or Building Research Establishment's Environmental Assessment Method (BREEAM) can be difficult. Another challenge is that foreign tools tend to be expensive and are not easily understood by the local developers and professionals (Darko et al., 2016; and Wu et al., 2022).

Can assessment of housing improve or reduce the negative effects that have been associated with housing development and what green building strategies can be in place to reduce the negative environmental effect of housing? According to MLGH, (2016) if housing in informal settlements is built in a sustainable way there will be a reduction on the demand on energy and there will be more sustainable provision of services such water and sewer disposal.

There is currently no provision for the use of green materials and methods in the building byelaws (NHP, 2016). Other authors have also emphasized the requirement for laws and policies that emphasize the use of eco-friendly techniques and materials (Alsanad, 2015 and Sabiu, 2020). The absence of the laws on GBTs means that professionals are not compelled to follow the green building strategies, thus little or no GB low-cost housing development is undertaken (Windapo, 2014; Aghimien, et. al., 2018; Zulu et al., 2020).

There is very little knowledge and experience of GBTs by the professions in the building industry and even worse by the local communities (Aghimien, et. al., 2018; Zulu et al., 2022; Sichali, 2017). A study undertaken among construction workers in Zambia showed that only 20 percent had knowledge of GBTs (Sichali, 2017). Onososen et al. (2019) claim that there is no guiding strategy to strengthen the technical skill of construction professionals in participating in GBTs. According to CIB Report, (1999), the lack of capacity in the construction sector to implement sustainable practices is a prominent barrier. William et al., (2016) identified lack of knowledge, understanding, and information as the major barriers to the delivery of sustainable structures.

One of the challenges in the development of green low-cost houses is the cost of GB materials (Aghimien, et. al., 2018; Zulu et al., 2022; Nikyema, and Blouin, 2020). A study undertaken in Zambia by Aghimien et al., (2018), found that fear of higher investment costs was the highest-ranked barrier to sustainable construction. According to Oyalowo (2016), the cost of construction is a barrier to the adoption of sustainable building practices.

The creation of the Sustainability Housing Guidelines (SHGs) by the Ministries of Local Government and Housing (MLGH) is a starting point on which GBTs could be developed. As stated in the Zambia Green Jobs programme of the International Labour Organization (ILO) (2016, p.2), *"the guidelines developed will spell out what GB are, as well as give performance criteria and guidance on social, environmental, and economic aspects including a checklist for measuring this performance."* (MLGH, 2016; Bungu, 2022; Agbajor, 2022). However very little is known about these guidelines and poor implementation could results into unsustainable low-cost housing in Zambia. The absence of documentation on GB activities indicates the lack of sustainability compliance. There is also the challenge of finding local experts to carry out the assessment, which can be quite complex and may include several procedures[1].

Zambia's problem is that it lacks the drive towards sustainable construction (Aghimien, et. al., 2018). Low-cost housing development goes on without the use of GBTs or even the SHG have not been directed towards implementation (MLGH, 2016; (Oke et al., 2019; Zulu, 2019).). Currently foreign based tools are used in Zambia, but it has not been established if these tools are appropriate for use in the development of green low-cost housing. These foreign tools do not consider a country's geographical/cultural position, architectural typology and available building materials and practices (Banani, 2011; Berawi, 2019; Anshebo, et al., 2022). Very little research has been done to establish the appropriateness of the current GBTs for Zambia. The problem seems to point to the absence of knowledge, technical skills, experience of GBs and the use of inappropriate criteria.

[1] Life-cycle cost analysis, Life-cycle assessment, simulation of energy flows and thermal indoor environment

1.3 Rationale

Zambia's housing and community amenities spending is expected to total K4.0 billion over the medium term, accounting for 1.5 percent of overall spending and an annual average of K1.3 billion (Ministry of Finance, 2019). This expenditure is inadequate to care for the huge demand for housing and its supporting infrastructure which are undertaken in an unsustainable way (NHP, 2016). According to UN-Habitat (2016), the infrastructure supply to most housing falls far behind both need and demand. There is insufficient investment in infrastructure, leading both to poor provision and grossly under-funded service providers (MLGH, 2016). About 70 percent of the country's urban residents live in informal settlements with poor access to water, sanitary facilities, and other amenities (Habitat for Humanity, 2015).

The development of GBs will reduce the cost of housing delivery as there will be efficient utilization of energy and other resources, as GBs use 25 percent less energy and 11 percent less portable water (Awadh, 2017; Mrkonjić, 2021). This reduced use of resources means that the cost of delivering low-cost housing will be lowered. Only when GBTs are used to measure the degree of sustainability can the level of development of GB be determined. GBTs have also been known to be a catalyst in the development of sustainable buildings (Assylbekov et al., 2021; Liu, 2022; Bungau et al., 2022).

The Zambian government has budgeted to spend $13.7 million on housing and related infrastructure (2020 budget) but, the cost of infrastructure could greatly be reduced if housing is planned and constructed sustainably. Research has also shown that there is a 20 percent reduction in the construction cost if buildings are built in a sustainable way (Kats et al., 2010; Nasereddin and Price, 2021). Reduction in the cost of construction and maintenance of buildings can benefit the urban poor. Apart from the cost of construction and maintenance, there are benefits in reducing the expenditure on energy in the buildings. Allen et. al., (2015) stated that GBs have a 30 percent reduction of energy used compared to conventional buildings. Zambia is facing challenges of inadequate energy and water supply, and GBs could contribute to reducing this demand. It is therefore necessary to investigate the use and knowledge of GBTs by the professions in the Zambia building industry.

The Ministry of Infrastructure, Housing and Urban Development (MIHUD) is mandated to develop housing. However, efforts to develop adequate housing have failed to reduce the 1.3 million housing deficit since 2016, projected to reach 3 million housing units by 2025 (NHP, 2016). Since the industry was privatized, the government's role in housing provision has decreased, and the urban poor have been left to take care of their own housing needs. Informal settlements have grown since independence, but the level of service provision has not matched this growth (PMRC, 2018, Chiwele et al., 2022). Literature advocates that sustainable building practices can lower housing infrastructure cost and ease the issues that the urban poor confront such as lack of access to building materials and inadequate energy in dwellings (PMRC, 2018; NHP, 2019).

The influence of building regulations and byelaws on the development of GB cannot be overemphasized. The current laws are silent on GBTs and so the players in the building industry may not see the need to undertake GB construction. Onososen et al. (2019) claims that there is no guiding strategy to strengthen the technical skill of construction professionals in participating in GBTs. It becomes necessary to investigate to what extent the absence of building byelaws is affecting the use of GB in the low-cost housing development. According to Liu et al. (2022), the issue is that the development and implementation of green buildings are constrained by a lack of government laws and technical skills by the professions. The current laws may also be archaic and not evolving with the changing time and have become irrelevant and too costly to follow by the urban poor (Kaatz et al.; and NHP, 2019).

The type of building materials can influence whether a building is green or not, thus GB materials must be available, affordable, and appropriate for use in the construction of green low-cost houses. There is no inventory on the type of green materials to use in Zambia. It becomes necessary to identify the materials to use for GB if appropriate strategies are to be implemented. Investigating the GB materials available becomes necessary to address the absence of GBTs in the Zambia low-cost housing development.

The SHGs are meant to encourage sustainable building development. The effectiveness of the guidelines to aid in implementing GB is unknown, and they need to be developed further into an assessment tool. The absence of local assessment tools could contribute to the slow pace of applying green technology in the building industry (Wang, 2018; Liu et al., 2022). This, in turn, could have contributed to the slow pace of certification of buildings. GB could develop if standards are set that all professionals and developers are mandated to follow.

1.4 Study Significance

Rating buildings is a scientific way of assessing the level of sustainability of the building, economically, socially, and environmentally. One way of promoting green housing is by taking evaluation on the level of sustainability attained. GBTs have been very instrumental in increasing sustainability actions and awareness amongst construction professionals towards making more sustainable choices (Griffiths et al., 2020). Even though rating buildings has a positive impact to attain sustainability the utilization of GBTs in Africa is low, and there is very little literature to shed light on this subject (Aghimien, et. al., 2018; Khan 2021; Anshebo, 2022). The professionals in the building industry lack skill in GBTs assessment, and the tools may not be affordable for most of them (Oke, et al., 2019).

It is important to undertake this study because it will explore the factors associated with achieving GBs in Zambia, particularly in low-cost housing. The study aimed to establish the knowledge and utilization of GBTs and their associated factors. Upon establishing the factors, GBTs can be developed in line with the environmental, economic, and social needs of the building industry. The development of the tool would be a significant addition to the already existing efforts being made to make housing development more sustainable. A lot of literature has outlined the factors associated with the use of GBTs; however, the research went further to explore solutions to these factors from the users themselves. It is important to have a critical look at the SDGs and the SHG and how they can contribute to the development of a GBT for low-cost housing in Zambia and this is what the study undertook.

The study is significant because it demonstrates the problem of unsustainable housing in Zambia and links it to associated factors. It shows how the existing laws on buildings can be improved for the development of green low-cost houses. The application of the SDGs in sustainable housing is shown and how the current rating tools cannot meet all the green building aspiration of individual countries, but an integration of various criteria could attempt to do so.

1.5 Purpose of the Study

The purpose of the study was twofold. Firstly, to establish what factors contribute to the use of tools and then secondly to investigate the environmental, economic, and social criteria key to the establishment of a GBT for the development of green low-cost houses in Zambia.

1.6 Objectives of the Research

1.6.1 Main objective

The overall objective was to develop a planning and assessment tool for green low-cost houses in Zambia, with adaptable environmental, economic, and social criteria and strategies.

1.6.2 Specific objectives

To fulfil the main objective, the specific objectives of the study were to:

i. establish the knowledge and utilization of GBTs in Zambia;
ii. explore the experience of the respondents in the use of GBTs and green strategies;
iii. investigate the factors associated with the use of GBTs in green low-cost housing development in Zambia;
iv. identify and rank the preferred environmental, social, and economic criteria for assessment of green low-cost housing; and
v. develop a tool for assessing green low-cost housing in Zambia.

1.6.3 Hypotheses

Hypothesis one

Green building development is new in developing nations as such, there is very little knowledge and no difference in knowledge among the professionals in the Zambian building industry.

Hypothesis two

There are factors associated with the use of GBTs for green low-cost houses. However, there is no association between the selected factors and the use of GBTs among the respondents.

Hypothesis three
There are several criteria used worldwide to achieve GB development, however among the respondents there was no difference in the preference of environmental, economic, and social criteria to be applied in the development of green low-cost housing in Zambia.

1.6.4 Research questions

The study addressed the following research questions:

i. How does knowledge and experience of GBTs compare among the players in the Zambia building industry?
ii. What factors are associated with the use of GBTs in low-cost housing development in Zambia?
iii. Which environmental, economic, and social criteria are important to use in the development of green low-cost housing in Zambia?

1.6.5 Research methodology

The study focused on finding the knowledge and utilization of GBTs and their associated factors by undertaking an analytical cross-sectional study. Analytical Hierarchy Process (AHP) and Relative Importance Index (RII) analysis was used to rank the preferred criteria and method of assessing GB. The study was a mixed-method design with a questionnaire survey and interviews to get both qualitative and quantitative data. Both desk studies and actual field investigations were undertaken.

1.7 Organization of the Thesis

The thesis is organized into seven chapters falling under four categories: theory, methods, results, and discussion and conclusion with recommendations. Chapters One and Two introduced the topic, gave some background on the subject matter, stating the study's objective, identified the research problem, and literature review. Chapters Three and Four compared the methodology and criteria of assessment of various GBTs, the study methodology and the process of undertaking the research and presents the results of the study. Chapter Five presented the discussion of the results. Chapter Six explained the tool development whilst Chapter Seven gives conclusions, recommendations, and limitations of the study.

The study covered seven chapters summarized as follows:

Chapter one the study's background, purpose, and objectives were provided. The significance of the research demonstrated the factors affecting the use of GBTs. The goal of the study was to identify the appropriate assessment technique and standards for GB in Zambia's low-cost housing.

Chapter two looked at a variety of published materials on GBTs knowledge and application to the creation of green, affordable housing. It identified factors associated with the use of GBTs. The evolution of GBTs was tabulated and the identification of environmental, social, and economic criteria used in GBTs were explored. Also examined were the processes of developing a GBT.

Chapter three explains the research methods used in the study. There was discussion on the research ethic and the study's methodology was laid forth in detail. Also, sampling techniques were chosen. Included were the theoretical framework and the problem tree analysis.

Chapter four analyzed the findings from both questionnaire surveys and interviews. The application and knowledge of GBTs were found. The parameters influencing the use of GBTs, and the preferred assessment method were determined. The SHG and 11^{th} SDG applications were also demonstrated in GBTs. The application of the method, criteria, and strategies to build affordable green low houses was also shown.

Chapter five discusses the ZIGBAT development. The framework of the tool is described along with its 6 components. Its evaluation standards are explained and how CASSUD, the 11^{th} SDG, and the questionnaire survey results are integrated. The various methods and criteria ranking are defined, and the validation is explained.

Chapter six discussed the findings from the questionnaire survey, the interviews, and literature review. Factors that may have an impact on GBTs usage, knowledge of tools in Zambia are examined. Key parameters in the tools were identified, and the processes and standards for evaluating GBTs were assessed. The results of this study were compared to those of other investigations so conclusions could be drawn from the research.

Chapter seven concluded by showing the knowledge and utilization of GBTs and how this could be improved. Factors associated with tool use were identified and remedies given to reduce their impact on attaining green low-cost houses. The identified criteria were demonstrated on how they could be used in Zambia. Recommendations are given for the various parties involved in low-cost housing development.

1.8 Summary

This chapter presented the background, aim and objectives of the study. The problem statement was based on the unknown levels of GBTs utilization in Zambia, and the indication of poor compliance with green building strategies in the country. The chapter also outlined the significance of the study to an economy riddled with power and water challenges and in need of economically and environmentally sustainable means of housing development. The study set to identify the appropriate method of assessment and criteria for GB in Zambia's low-cost housing. The next chapter reviews existing GBTs, their development, use and challenges. The review of literature also presents factors associated with the utilization of GBTs and makes a comparison of the type of criteria in the tools.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Chapter One presented the study's background, aim, objectives, and significance. The problem statement was premised on the unknown knowledge and utilization GBTs in Zambia and the need to develop sustainable low-cost housing with environmental, social, and economic parameters. The lack of evidence of GB compliance for low-cost housing development in Zambia could hinder the attainment of sustainable housing. There is also unavailability of local assessment tools to evaluate housing development in the country. This chapter reviews literature on the environmental, economic, and social factors contributing to the development of green low-cost houses in Zambia. The possibilities of attaining green low-cost houses through local tool development is explored.

2.2 Low-Cost Housing Development

By 2025, 1.6 billion people will have housing challenges (World Bank, 2020; WEF, 2022). The housing problem is being exacerbated by a shortage of land, finance, labour, and building materials. To accommodate the predicted 3 billion people who will need access to sufficient housing by 2030, the globe needs to construct 96,000 new affordable homes every day (UN-Habitat, 2019; URBANET, 2022; World Bank, 2022). Low-cost housing could be a solution to the global housing need as they can be built quickly with minimal resources. Unfortunately, even the required modest home is out of reach for most urban people. Housing in an urban environment faces difficulties since building codes forbid the use of some readily available building materials and demand the use of more standardized ones which tend to be expensive. Because building materials can be used more creatively in rural regions than in cities, construction there is simpler. The delivery of housing is being made with an eye toward improving levels of social inclusion and cohesion, economic access, and productivity while having the least detrimental environmental impact possible.

Low-cost housing is a novel idea that deals with good budgeting and following procedures that help in decreasing the cost of building by using locally accessible materials together with better skills and technology without compromising the strength, performance, and lifespan of the structure (Barot, 2021; Chauhan et al., 2019). This kind of housing does not mean substandard buildings but rather an effective way of constructing homes with minimal cost on building materials and project management. There are different understandings of low-cost housing and could be based on affordability, income level and size of dwelling. According to Herbert et al., (2021) 30 percent income criterion is a frequently used and recognized indicator of the severity of the nation's housing affordability issues. House price is the most crucial factor for homeownership preferences, according to a study by Zainon et al. (2017), and it has been a big issue for households, especially for those residing in major cities. Therefore, the size of the house dictates how low the cost will be and usually would range between 50 to 150 sqm in size (NHP, 2019).

The provision of low-cost housing should allow for comfort, functionality, safety, and security of the homeowners and is a fundamental human right. According to the UN the right to adequate housing is a human right recognized in international human rights law (UN Habitat, 2019). Despite this right's prominent position in the international legal system, well over a billion individuals are not sufficiently housed. Millions of people worldwide live in unsafe or unhealthy environments, in overcrowded slums and unofficial settlements, or in other situations that are inhumane and violate their dignity and human rights (UNHRP, 2019).

Many elements, such as the style and size of the residence, the number of rooms, or the size of the surrounding property, are taken into consideration when determining low-cost housing. How far away from the transportation system, the crime rate, the caliber of the neighborhood schools, the population's racial or ethnic mix, green spaces or parks, and the proportion of residential areas that rely on cars (Boyle, Barrilleaux, & Scheller, 2014; Cervero & Li et al., 2015 and UN Habitat, 2019). Through sustainable housing the various facades looked at earlier can be achieved. Secure tenure of land is necessary to guarantee the legal protection of low-cost housing residents from forced evictions. Safe drinking water, proper sanitation, energy for cooking, heating, lighting, and food storage or waste disposal are just a few of the necessities that must be present (UNHRP, 2019). It must be within the reach of the urban poor, who must be able to pay monthly or obtain loans at reasonable rates. The homes should be livable in the sense that the residents feel secure and at ease and that they are protected physically from elements, such as cold, moisture, heat, rain, wind, and structural risks. Users of affordable housing, especially those from disadvantaged and marginalized groups, should have access to it too. It must be situated close to amenities for adequate transit, employment, healthcare, education, childcare, and other social services. Consideration of cultural identity is essential since it must be respected and considered (UN Habitat, 2019). Therefore, without looking at sustainable housing it becomes difficult to achieve decent housing.

2.3 Sustainable Development

Although there are many ways to interpret the idea of sustainable development, at its core it refers to a method of growth that seeks to strike a balance between various, frequently incompatible needs and an awareness of the social, economic, and environmental constraints that our society is subject to (SDC, 2011). Sustainable development was described as *"development that meets the requirements of the present generation without compromising the ability of future generations to meet their own needs."* (Brundtland Report of 1987). From this standpoint Thomas (2015) continues that sustainability brings into focus human activities and their ability to satisfy human needs and wants without depleting or exhausting the productive resources at their disposal. Stoddart (2011) defines sustainability as "*the efficient and equitable distribution of resources intra-generationally and inter-generationally with the operation of socio-economic activities within the confines of a finite ecosystem*". Sustainability requires that communities meet their human needs without jeopardizing the integrity and stability of the natural system. Human needs include all the three arms of sustainability (environmental, economic, and social). According to DESA-UN (2018), the main goal of the idea of sustainability is to maintain proper alignment and harmony between society, economy, and the environment in terms of the ability of the planet's life-supporting ecosystems to regenerate.

The issue of sustainability is key to the developmental goals of many nations, especially developing ones. These nations must develop with sustainability in mind as they are hit with challenges of global warming and climate change. In housing development there is a high need for resources and if these resources are not utilized carefully, they border on unsustainable development and put pressure on the available resources. Sometimes in the quest to achieve low-cost housing resources are exploited like the quarrying of stones and the depletion of forests.

Buildings and cities worldwide produce both outdoor and indoor air contamination, which includes air, water, soil, noise, and light pollution. This effluence includes carbon emissions from the construction process, which has a well-documented environmental impact due to garbage production, water consumption, dust production, and greenhouse gas emissions (WGBC, 2018). Other pollutants that could be reduced through the GBs are lead, mercury, and asbestos exposure. Also, air pollutants are a large burden of health risks associated with indoor and outdoor biomass burning. Determining affluence levels and halting their impact on the ecosystem at the source of contamination can be a challenge. Pollution caused by home development in Zambia raises issues about water and air quality, both of which have an impact on housing quality. Faecal waste from pit latrines has contaminated the subterranean water, and there is a lot of biomass burning, which poses health risks such as carbon monoxide poisoning in homes. The identified challenges can be addressed by building green low-cost housing in developing countries such as Zambia.

Zambia continues to face difficulties in ensuring environmental sustainability due to high rates of deforestation and limited access to renewable energy, clean drinking water, and sanitary facilities (UNDP, 2020; Phiri, 2016; Munshifwa, et al., 2021). As a result of unsustainable development, the country has had severe effects of climate change resulting in extreme weather conditions, such as droughts, rising temperatures, and unpredictable rainfall patterns. There is a lot of greenfield development in Zambia rather than brownfield enhancement, which has put a lot of strain on the government to supply services to far-flung areas. There are challenges in implementing this criterion due to uneven land distribution and poorly planned and managed sites. Pressure for the development on green fields has led to the growing demand for land-use changes, allocation, and building in environmentally sensitive areas. This poses major environmental hazards because of the pollution of water sources by home and industrial waste (Munshifwa, 2021). However, the country's recent 600 MW drop in hydropower production is primarily due to unfavorable rainfall patterns (Obahoundje, et al., 2022; Kaunda, 2015).

Additional unfavorable effects of climate change include an increase in disease load, including malaria, as well as habitat destruction, infrastructural damage, and disruption of biodiversity (Short et al., 2017; Rocha et al., 2022). The Zambian government has desired to effectively mainstream climate change challenges through the Seventh National Development Plan (7th NDP, 2017). This Plan has integrated mitigation and adaptation strategies for climate change; these are anticipated to improve societal well-being, including greater health and economic growth, while also lowering environmental threats including water scarcity, air pollution, and other repercussions (7^{th} NDP, 2017). But if housing continues to be built in an unsustainable way the realization of the 7^{th} NDP will be difficult.

2.4 The Sustainability Development Goals

The 1992 Rio de Janeiro Earth Conference launched the Rio Process, which was the first attempt to institutionalize sustainable development. The United Nations General Assembly (UNGA) endorsed the SDGs (2015–30) in 2015 and provided an explanation of how the goals are interconnected to achieve sustainable development on a global basis. Global challenges including poverty, inequality, climate change, environmental degradation, peace, and justice are addressed in the pursuit of sustainability (Purvis et al.,2019; Agheli and Taghvaee, 2022).

The UNGA formulated the SDGs in 2015 as part of the Post-2015 Development Agenda, which aimed to design a new global development framework to replace the Millennium Development Goals, (Biermann, 2017). To mitigate the effect of climate change, United Nations Member States adopted the 2030 Agenda for Sustainable Development in 2015. They were a global call to action to eradicate poverty, safeguard the environment, and guarantee that by the year 2030, peace and prosperity will be experienced by everyone. The 17 SDGs understand that development must balance social, economic, and environmental sustainability and that actions in one area will have an impact on results in others (FAO, 2020).

The SD performance of African nations was found to rank lowest around the world (Bilbao, 2013; Li et al., 2014; and Hickel 2019). Also, most of the recent research have shown that the continent of Africa needs the most attention and that raising the SD levels of African nations is essential to reaching the global SDGs (Jin et al., 2020; Li, 2021). The leading SD countries have attained a high level of SD, the middle-level SD countries have found a way to raise SD, while the low-SD countries (mostly in Africa) are still unable to thrive.

Green low-cost housing development can help achieve some of the SDGs that have to do with the built environment. For example, SDG 13 on climate action, SDGs 3 (health), 7 (clean energy), 11 (cities and communities), and 12 (responsible consumption and production), can be realized in green low-cost housing development (Machingura and Fortunate, 2017).

2.4.1 The application of sustainable development goals in housing

The 2030 Agenda for Sustainable Development includes housing as a key element, and housing is an important factor in reaching several of the SDGs. Having access to sustainable housing has a positive impact on economic, educational, and health outcomes (Habitat for Humanity, 2021; Liu, 2021). There are greater community profits from these improvements because they lessen inequality and increase preparedness for calamities both man-made and natural (Habitat for Humanity, 2021).

The promotion of sustainable housing development is supported by the 11th Sustainability Development Goal (SDG). According to the UN Department of Economic and Social Affairs Sustainable Development (UNESASD) (2020), making cities sustainable means creating careers and business opportunities, safe and affordable housing and buildings, resilient societies, and economies. The need to improve housing is seen in the number of slum dwellers in developing countries. In 2018, there were more than 1 billion slum residents, or 24 percent of the urban population (UNESC, 2020). In 2019, just 50 percent of people residing in metropolitan areas had easy access to public transportation, which is defined as being 500 meters or less from a low-capacity system (like a bus stop) and one kilometer or less from a high-capacity system (such as a railway) (UNESC, 2020; Rodrigue, 2020). Most urban regions saw an overall increase in the amount of built-up area per inhabitant between 1990 and 2015 (UNESC, 2020).

The focus of the study is to show how SDG 11 can be applied in the development of green low-cost housing. The goal encompasses consideration of public transport, creating green spaces and improving urban planning and management in a shared and broadway. Green housing is dependent on social-economic initiatives and environmental policies. It cannot be achieved by looking at the building fabric only, but it must promote social cohesion, where communities can interact socially and economically (SDG, 2015). By separating SDG parameters that concern buildings and the surrounding environment and demonstrating these techniques, SDG targets could be realized in the design and construction of GBs.

2.5 The Environmental, Economic and Social Concerns for the Development of Green Low-Cost Housing in Zambia

The three wings of sustainability (Environmental, Economic and Social) are vital in the preservation of our environment. Non can be achieved without the other influencing or affecting the other. Considering all the wings of sustainability safeguard the environment with environmentally friendly measures that allow for long-term ecological quality to preserve it for future generations (Balsalobre-Lorente et al., 2018; Rajalakshmi, 2016). According to the term triple bottom line, sustainability depends on the balance between the three pillars: environmental, social, and economic. Environmental sustainability focuses on maintaining the quality of the environment, social sustainability strives, e.g., to ensure human rights and equality, and economic sustainability is important when maintaining the natural, social, and human capital required for income and living standards (Jeronen, 2020).

The three pillars of sustainability, economic viability, environmental protection, and social equity are vital to achieve the redistribution of income, global gender equity, and the reduction of extreme poverty in the quest to become sustainable (Purvis et al., 2019). Sustainable development requires the contribution to economic growth, social progress and promote environmental sustainability (Barbier and Burgess, 2017; Mensah, 2019; Singh et a., 2022). The environment is now looked at in the light of supporting the economic and social growth of societies. Natural ecosystems play a crucial part in providing the resources on which society depends, such as food and water, the control of the temperature, the cycle of nutrients, and crop fertilization (Mensah, 2019; Singh et a., 2022). Also, they sustain diversity while offering recreational advantages. Achieving environmental sustainability while improving the standard of living for the world's poorest people, who rely mostly on farms, forests, and rivers, requires the maintenance of healthy ecosystems (UN Economic and Social Affairs, 2008; Jeronen, 2020).

2.5.1 The environmental sustainability of housing

According to Spera, Magazine, (2020) “Environmental sustainability is the responsibility to conserve natural resources and protect global ecosystems to support health and wellbeing, now and in the future”. Concerns for environmental sustainability include air, water, soil, and wildlife habitats. These resources must be used in a way that causes the least amount of harm to the environment during their extraction. Many developing countries highly depend on their natural resources for the provision of energy and the use of these resources puts a heavy toll on the environment. For example, while some developed countries have moved away from the use of coal, these developing countries do not have the technology to use renewable sources of energy. Therefore, there is usually a tradeoff in trying to reduce environmental degradation and meeting the needs of communities.

Zambia is built on a rich and mostly irreplaceable foundation provided by the environment. The vast environment richness is seen in the amount of vast arable land, fresh water, and minerals. Its rich biodiversity and sceneries provide a tourism product (Aongola, 2009; NCCRS, 2010a). However due to poor management of the natural resources the negative effect of climate change has been felt across the country with huge issues like energy scarcity, drought, flooding, depleted of wildlife and timber and pollution (ZECCP, 2010; Byaro, 2022). The continued environmental degradation strongly indicates that the Zambian state largely fails to sustainably manage its environment and natural resources (ZECCP, 2010; Byaro, 2022). Environmental degradation limits the economic potential for low-income people by reducing agricultural output and limiting access to other resources. For poor households generally, and for children, indoor and outdoor water, and air pollution as well as limited access to clean water and sanitation have substantial negative health effects (UNICEF, 2011). The urban poor are mostly affected by environmental issues, such as a lack of access to clean water and sanitation, indoor air pollution brought on by using obsolete cooking appliances and solid fuels, hazardous and unstable land conditions, and solid waste issues (Aongola, 2009; Dietler, 2021).

Son et al., (2011) found that emerging nations, such as Zambia, had the biggest environmental effect from the construction industry, as they strive to industrialize. The building industry significantly contributes to unsustainable development, and it has a significant negative influence on the environment (Ametepey and Ansah, 2015; Du Plessis, 2002; Yao et al., 2020). Due to excessive use of raw materials, scarcity has driven up construction costs, particularly for building affordable housing, because it has become more expensive and labor-intensive to extract the raw materials. The huge demand on building materials has resulted in numerous burrow pits where water collects and adds to the infestation of mosquitoes with elevated levels of malaria and an increase in the disease burden of communicable diseases (ZECCP, 2010; Byaro, 2022). To reduce the damaging environmental consequences that buildings have on the environment, sustainable development is essential. The employment of sustainable building techniques will ease the burden on the supply of building materials and support the advancement of construction activities to address the shortage of houses on the market.

2.5.2 The Economic Sustainability of Housing

After experiencing a 2.8% drop in 2020 due to the pandemic, Zambia's economy recovered in 2021 with GDP expanding at a rate of 4.6%. High copper prices, post-election market confidence, and ongoing agricultural revival all contributed to the economy's rebound (World Bank, 2023; Geda, 2021). The economy has continued to grow over the first half of 2022. Economic sustainability could play a role in improving the country’s economic growth. The term economic sustainability refers to actions that promote long-term economic growth without having a negative effect on the community's social, environmental, and cultural facets (Spangenberg, 2005; Niekerk, 2020). Strategies must be in place so that the economic activities are undertaken while making sure the other pillars are positively affected over the long term with the available resources. Economic sustainability can be the bedrock on which the other pillars can be achieved.

Building construction has been a factor in economic growth. It is a measure of the prosperity of a country and where there is growth in the building industry the economy of a nation will grow (Pheng and Grönkvist, 2019; Tian & Li 2019). An efficient use of resources like energy and water is one way in which economic sustainability can be achieved as the overall cost of such services is reduced on the national budget. Economic sustainability can be realized through investment into energy-efficient building methods, environmentally friendly infrastructure, water and waste-water management, well-planned communities, and effective transportation (Zhong and Wu, 2015; Al-Shetwi, 2022). By using less water, electricity, gas, and other resources, sustainability best practices save money for both citizens and countries. These local savings can subsequently be used to finance additional local economic activity and investments.

According to Zambia's high-level Vision 2030, there is genuine potential for the country to develop an economy "based on sustainable environment and natural resource management principles"(NHP, 2019). Zambia could do well if in their budgeting thought went to the management of the environment so that resources are used in a sustainable way. Resources can be available but if not properly managed the benefits will not be felt by the urban poor who make up most of the urban population. For example, Zambia is endorsed with mineral resources, vast water bodies and woodland but it is failing to provide adequate electricity and clean water and it cannot use its woodlands to produce sustainable building materials. According to Li et. al., (2021) while energy use, arable land, and forests serve as indicators of the state of the environment and the availability of resources, they have an impact on how well economic activities perform.

According to SHG, supporting the local economy and creating jobs are key components of economic sustainability. This is accomplished by seeking goods and services from the neighborhood and by sustaining employment for maintenance and other services needed in the housing industry. More local employment and a diverse home-grown economy can be attained through the encouragement and growth of neighborhood small businesses. By providing opportunities to bid on pertinent construction and maintenance contracts, the construction process can boost local capacity, lowering the cost of housing through building materials, maintenance, and effective delivery (Zulu et al., 2020). Housing developments that specify local materials and components can operate as a powerful motivator for local manufacturers and suppliers to create and deliver the necessary goods and capacity (MLG, 2016). In the SBAT economic sustainability is achieved through efficiency, adaptability and flexibility in the construction process and material procurement. The promotion of local community involvement using local labourers and local building materials (Gibberd, 2010).

2.5.3 The social sustainability of housing

To maintain the variety of social relationships that exist in healthy societies, social sustainability must be ensured. Engaging with the inhabitants of those locations is necessary to develop the physical, cultural, and social environments that promote wellbeing and a feeling of community (Palich, N. and Edmonds, A., 2013). By creating surroundings that assist communities in satisfying their social demands, buildings enhance social sustainability. Social value refers to those factors that affect liveliness of a community, such as health and wellbeing, security and resilience, equity and accessibility, and stems from results that have a favorable impact on overall quality of life (Wilson, 2018; Pococka, et al., 2016). Although social sustainability indicators are applicable worldwide, developing nations may need to consider other social or human sustainability issues. Therefore, social factors differ from region to region.

According to the Sustainability Housing Guidelines (SHG) of Zambia, social sustainability includes access, health, education, inclusion, and social cohesion (MLG, 2016). Access to housing is when there are facilities that allow easy access to accommodation, these may be safe passage into buildings with road work or paths. It can be the provision of staircase or ramp or safety on the outside and inside of the building. Health may be the prevention of diseases in buildings, safety of occupants from occupational hazards and housing that promote good health habits like sufficient air circulation or good healthy building materials. It also includes the provision of health facilities in the vicinity of housing. In terms of education the guidelines promote housing that enables occupants access to schools or any learning facilities. This means the promotion of schools in housing development. Inclusion is the promotion of all social groups in housing provision, whether this is differences in ethnicity, age sex, or culture. Housing should also support social cohesion. Social cohesion is when communities can interact due to the facilities around them like social amenities (MLG, 2016; Gibberd, 2010; Pococka, et al., 2016). According to Gibberd (2010) social sustainability concerns itself with human comfort both indoors and outdoors. The occupant's comfort includes both physiological and biological. Buildings should be inclusive in that occupants do not have constrains based on their ethnicity, sex, age, or culture. There should also be easy access to buildings with their supporting infrastructure like schools, recreational facilities, and hospitals. Despite its importance as an engine, excessive vehicular movement contributes to high energy consumption, which results in air pollution, particularly nitrous oxides, and particulates, and contributes significantly to global warming. Because of an inadequate public transportation system near new housing development, the usage of private vehicles has increased, resulting in greater demand for petroleum and pollution-emitting products. There is a need to increase mobility options like buses, cycling and walking, if this is to be achieved.

2.6 The History of Housing Development in Zambia

One of the most urbanized nations (46 percent) in Sub-Saharan Africa, Zambia has a great need for infrastructure and basic services, notably in the housing sector (Crankshaw and Saladin, 2019; Satterthwaite, 2017). Like many other countries Zambia is struggling to provide adequate housing for its population looking at a 2 million housing deficit (Phiri, 2016; Makasa, 2016; NHP, 2019). The development of housing in Zambia is connected to its political history. During the colonial era housing was to be developed in the urban centres for administrative purposes, while for the native people it was to be temporal and of poor quality. Housing was developed along the line of rail and Government had direct control over housing supply and regulation during the colonial era (1924–1964), as well as over its quality and who lived in it. The Employment of Natives Law of 1929 obliged all employers to furnish accommodation, while a system of pass laws limited the number of indigenous Zambians who resided in towns (Phiri, 2016; PMRC, 2018; Zulu, 2019).

The post-colonial era saw the government inheriting segregated cities with some areas having good housing while others around the periphery of the central business district having poor housing and infrastructure. Due to the abolishment of pass regulations this led to a significant increase in the number of people moving into urban areas and resulted into severe lack of suitable housing, especially in Lusaka, the Copperbelt, and other towns along the Line of Rail (Phiri, 2016; PMRC, 2018; Zulu, 2019). From 1964 onwards the government embarked on mass housing development through the councils and the mines, but the economic downturn of 1970 reduced the ability of these two entities to provide housing and housing shortage cripped in. The strategy at the time of independence was outlined as part of the wider national development strategy in 5-year National Development Plan. At this time, housing was seen as a social right, and it was primarily the role of the government to oversee and build housing by parastatal organizations and municipal governments (PMRC, 2018; NHP, 2019; Makasa, 2016; Zulu, 2019). The MMD government's neo-liberal, market-based, and economic liberalization policies, which were established in 1991, came up with a variety of policies and legal frameworks for housing in the 1990s. These regulations boosted home ownership, promoted private sector investment, and provided financial incentives to the housing sector (PMRC, 2018). Despite these policies there was government failure to finance the development of housing thus the housing deficit.

Because government was no longer providing serviced land and the budget allocation for housing was reduced to 1 percent from 15 percent many of the urban poor could not be catered for in the provision of housing (Phiri, 2016; PMRC, 2018; NHP, 2019; Makasa, 2016). The councils, after selling off their housing stock, were not able to reinvest in housing thus there was no continuity in the provision of affordable housing. Land has also become scarce for most of the population. The 1995 Land Act was passed by the Zambian government with the intention of boosting the economy and eradicating poverty. It provided new legislation on land usage and land reforms (Brown, 2005). Most of the population in informal settlements have no right to land tenure as they have no titles to the land that they occupy. Over 70% of city people live in unplanned settlements and have no legal right to land. The land is characterized with poor access to safe and clean water, sanitation, hygiene, and extension services since there is a scarcity of affordable housing (Habitat for Humanity, 2019). Inadequate access to affordable and good housing in Zambia, as noted in the Sixth National Development Plan (7^{th} NDP, 2011-2015), poses a significant difficulty for the Zambian government as it works to provide basic services to the entire population (Republic of Zambia, 2011).

The lack of low-cost housing, which had been started after independence is to blame for the emergence of unplanned urban communities in Zambia. After independence, successive administrations have been unable to find a long-term solution to the problem of providing appropriate housing in metropolitan areas that are continuously expanding (Zulu, 2019; Makasa, 2016; CHHFZ, 2022). Key reforms were made, for example the price of goods and services were to be determined by the market force and this increased the cost of housing and infrastructure delivery. With no subsidies on low-cost housing, it meant that the urban poor had to fend for themselves to source land and finance for housing (PMRC, 2018; NHP, 2019).

According to the NHP the current regulations are outdated and apply only to formal housing, leaving out informal housing. The laws were developed using British standards which could not be applied completely on the Zambia building industry considering the difference in the physical environment. The building byelaws promote materials that are not sustainable and are too costly to apply to low-cost housing development (Makasa, 2016; Zulu, 2019).

2.6.1 The state of housing in Zambia

The total number of housing units in Zambia is projected to be 2.5 million, with conventional housing making up 64 percent and urban housing making up 36 percent (or roughly 800 000 units) (PMRC, 2018). Zambia has a housing deficit 2.5 million and it is estimated that it would need 1.3 million new homes between 2011 and 2030 (NHP, 2019; PMRC, 2018; CHHFZ, 2020). Around 40 percent of urban housing is considered high quality, and 60 percent is of poor quality. About 20 percent of the city's land is used for residential purposes, and nearly two thirds of its residents live in substandard informal housing as seen in Figure 2.1, which accounts for nearly 80 percent of the city's housing stock. (MLGH, 2016; PMRC, 2018). This housing stock is described as having limited or no formal services such as electricity, water, and sewage. The poor economic climate has had a negative impact on the housing sector's performance. There is high inflation and interest rates, and the cost of housing financing and construction materials makes them unaffordable (Schlyter, 2000; Zulu, 2019; Makasa, 2016) This has a detrimental effect on the standard of living and the pace at which homes are constructed.

Figure 2-1 *Poor housing structure*
(After author's source, 2016)

Through the NHP the government has been encouraging the use of local sustainable building materials as stated "*streamlining building standards, regulations, and other controls to meet the needs and capabilities of various segments of the population; ……. encouraging the production and use of local and affordable building materials*" (GRZ 1996). Access to building materials used for the development of low-cost housing also varies, depending on the involvement of building professionals. The materials used in constructing low-cost houses vary from concrete blocks to clay bricks and the use of iron sheets. Most of the time these local materials are affected by the environment as they are easily washed away by heavy rains, since binders like cement is reduced to cut down on cost of the materials, they cannot stand extreme weather patterns.

The environment around the housing lacks basic services and is challenged with poor drainage and solid waste disposal as seen in Figure 2.2 below. Due to poor water and sewage disposal disease outbreaks like cholera and dysentery are common in such settlements. There has been an association between poor housing and disease outbreak, for example overcrowding in housing increases the transmission of respiratory d
iseases such as tuberculosis (TB) and bronchitis due to poor ventilation and dampness (Lienhardt, 2012; Purvis et al.,2019; Agheli and Taghvaee, 2022).

Figure 2-2*:* *Housing with poor drains and covered with solid waste*
Source: Author, 2015

Due to the high cost of constructing low-cost houses, many residents have opted to use substandard materials and these houses are subject to dilapidation and collapse with severe weather patterns due to climate change as seen in Figure 2-3. The surrounding environment usually experiences flooding and flashfloods. Poor waste management has caused many of these areas to flood as waste clogs drains (UN, 2020).

Figure 2-3*:* *flooding due to poor drainage.*
Source: DDMU, (2022)

The application of the byelaws in these communities is not there as many of the residents do not submit their building plans to the local authorities and most of them build with little supervision from the building professionals. The submission of building plans is costly for most of the residents and the use of cheap building materials is common (NHP, 2019).

2.7 The History of Green Buildings

After World War II, the economic depression of 1945 created an urge to reduce the demand for fossil fuels and the use of concrete for more sustainable materials such as steel and glass, considered to have a low carbon footprint (Penna, 2022). However, buildings with glass and steel required the use of air conditioning (HVAC) systems that demanded a huge amount of electric energy. This required energy was in short supply, and many architects and engineers thought about making their structures more energy efficient. According to Building Design and Construction magazine, (2006), the 70s to the 90s saw a growing *"Green Movement"* that anticipated the earth's resources to be looted rather than being carefully harnessed and utilized. A forward-thinking group of architects, environmentalists, and ecologists were motivated by the expanding environmental movement and the rising fuel prices that were common throughout the 1970s around the time that the *"glass box"* style high rise had become the symbol of the American city (around 1970). These two events served as the inspiration for the present green building movement (Sabbagh et al., 2022). As the global population became more aware of their actions and their consequences on the environment, the construction industry, like many others, realized that it could play a part in decreasing greenhouse gas emissions in the design and construction of buildings.

A United Nations conference held in Stockholm in 1972 marked the first occasion on which sustainable development was recognized as an international concern (UNCHE, 1972). Aykan (2013) stated that the emerging eco-development ideas sought to achieve objectives through environmentally friendly management. The Oil Producing and Exporting Countries (OPEC) oil embargo of 1973 led to questioning the dependency on fossil fuels. In the end, the construction industry began to integrate concepts of sustainability into its activities.

2.7.1 Development of green building rating tools in the world

The theory, science, and fashion of structures designed and built in line with ecologically friendly principles is known as the concept of green architecture, sometimes known as "*sustainable architecture*" or "*green building*." In addition to reducing the amount of resources used in the building's construction, usage, and operation, green architecture aims to lessen the damage that its constituent parts cause to the environment through emissions, pollution, and waste (Ragheb, 2016; Bungau, 2022; Sepehrdoust, 2022). According to the United States Green Building Council (USGBC, 2012, p.2), "*green building is the practice of creating structures and using environmentally responsible and resource-efficient processes throughout a building life cycle*." This involves everything from building, siting to design, construction, operation, maintenance, refurbishment, and demolition. The practice expands and complements the conventional building design concerns of economy, utility, durability, and comfort (Cullen, 2010; Ragheb, 2016; Bungau, 2022; Sepehrdoust, 2022). This study defines GB as buildings whose design process, material selection, construction, utilization, and demolition consider resource use and construction process with a minimal negative impact on the environment. The definition took into consideration the social and economic characteristics of the environment.

The amount of building construction going on in the world has brought deep concerns about the impact of construction work on the environment. With 32 percent consumption of resources and 40 percent waste coming from buildings, there is a need to keep track of green compliance, hence the rating of buildings (Tafazzoli, 2017; Bungau, 2022; Lu, et al., 2018). Rating buildings is one of the processes of finding out the level at which the buildings are impacting the environment (Karimi et al., 2022). Empirical evidence is important to quantify the sustainability performance of buildings. The rating of building projects to gauge their level of sustainability or greenness to the environment has increased drastically over the years. The number of green building assessment tools has grown too. As stated by GBCA (2016) the total number of tools or methodologies for building assessment and benchmarking is around 150. According to the GBCA (2016), as of October 2016, over 145,000 green certification projects were completed around the world. Globally the percentage of firms with over 60 percent of their projects certified green was projected to grow from 18 percent in 2016 to 37 percent by 2018, with a more significant proportion from developing markets (World Green Building Trends Smart Market Report, 2004).

The British Research Establishment Environmental Assessment Methodology (BREEAM), developed in 1989, was the first real attempt to establish a comprehensive rating tool followed by Leadership in Energy and Environmental Design (LEED) (Haapio, 2008). Others include the Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB), the Japanese Comprehensive Assessment System for Built Environment Efficiency (CASBEE) and the Green Star of Australia and South Africa.

The prominent rating tools shown in Figure 2.4 were established, particularly in developed countries, and spread to the rest of the world. However, Africa has the least number of tools generated or used (McArthur, 2015). Over the last ten years, some African countries have developed or adapted rating tools from other regions, like Europe or the USA. South Africa and Kenya have adopted the Australian Green Star, while Egypt has several rating tools (ESTIDAMA v1.0; Green Pyramid Rating System and TARSHEED Residential), all a replica of the LEED tool. The low number of GBTs in Africa could be due to a lack of economic and political drive to develop sustainable buildings.

Figure 2-4: A world map of GBTs

(After Reed et al., 2011)

2.8 Development of the Green Building Strategies in Africa

Africa has been putting up GB as far back as the beginning of civilization along the Nile River. The materials available and some of the construction techniques passed on from generation to generation enabled sustainable structures to be built. Over the years, Africa did not move on as fast as their European or North American counterparts in discovering new building materials that were harmful to the environment. For example, the discovery of cement, while beneficial in terms of building stronger and faster constructions, has increased the carbon footprint (Almusaed, 2015; El-Husseiny et al., 2022). The old buildings constructed out of mud or adobe bricks tended to be sustainable because they enabled buildings to be cool inside; thus, less artificial ventilation was required (El-Husseiny, 2022; Almusaed, 2015). Ancient Egypt has been known to practice green building technology in constructing the pyramids and their temples. These structures were constructed from local materials, and the citizens were the masters of their building techniques (Calvert, 2021). The buildings were constructed using sustainable resources such as clay, stone, and wood. The materials had low embodied energy and were easy to utilize, accessible, and adaptable for most people (Nasr and El-eashy, 2022). African rural houses erected with clay and thatch are sustainable with good internal conditions, allowing them to be cool when it is hot and warm during the night. Most of these houses have lost their greenness because of the influx of cement and other building materials from outside the continent. Developing nations have a high life cycle cost (LCC) on their building materials and high embodied energy, making them unsustainable (Tessen et al., 2015).

The challenge that Africa faces is the indiscriminate use of resources and a lack of accountability for the impact of these activities on the environment (Juma and Miraji, 2018). The challenge of poor utilization of resources has reversed all the efforts made to go green. Even though African architecture has been known to be green, very little has been done to improve the technology (Agbajor and Mewomo, 2022; Juma and Miraji, 2018). The technology lacks scientific evidence to prove that it has a low impact on the environment. Another challenge confronting sustainable development at the building scale is the insufficient application of green strategies suitable for the region. There is an absence of knowledge to evaluate green structures and financial incentives for GB development (Aghimien et al., 2018; Alabi 2012; and Aje 2016).

There are extremely few GBTs in Africa for various reasons, one of which is a lack of enthusiasm among investors and occupants in building sustainably (Mush, et al., 2022; Zulu, 2020; Aje, 2016). The challenge in Africa is that it lacks the economic and political drive to adopt green strategies in building construction that are adaptable to its environment (Aghimien et al., 2018; Mushi, et al., 2022; Liu, 2022). Some studies have shown that the sustainability level in construction projects delivered in developing countries is low, and Zambia is no exception (Alabi, 2012; Aje, 2016; Baron and Donath, 2016; and James and Matipa 2004). Developers feel that trying to make a building sustainable comes with additional costs.

Not more than 500 buildings in South Africa or Egypt were certified, those certified are mostly commercial structures (World Bank Report, 2016). According to Frost and Sullivan (2010), the green construction business in South Africa is still in its infancy. Studies like Alabi (2012) and Aje (2016) have shown that the sustainability level in construction projects being delivered in developing countries is low. There is no market to take up that extra cost of going green. Life Cycle Assessments (LCAs) incorporated in these tools require a lot of data (Lui, 2022; De Wolf, et al., 2023; Baron and Donath, 2016). Collecting and updating the needed information can involve substantial costs (Liu, 2022). According to Khan (2021), the expenses associated with GBTs make them unreachable to many building professionals and, as a result, make assessment levels subject to economic declines.

Malanca (2010) notes that Africa has very little green labelling or certification due to the seemingly small market size and slow adoption of GBTs. However, the slow progress could be exacerbated by financial implications involved at various stages of the assessment and accreditation processes. Green initiatives are heavily reliant on government funding in most developing nations. Because most authorities in developing countries have more pressing priorities, they do not participate in such projects but instead leave it for the private sector to be engaged. Furthermore, due to a lack of government involvement, the private sector does not feel obligated to participate in the creation of GB. As stated by Liu (2022), there is also a lack of interest by both developers and professionals in advocating for the use of GBTs in most developing countries.

Others feel that there are no regulations to force people to build sustainably. Policy direction on sustainability is so generalized that it has very little impact on the building industry (Saha, et al., 2021), however Wong et al., (2021) in their study found that the most important barrier was the lack of market demand on green building rather than policy direction. The private sector is playing a significant role in the promotion of GBs as seen in the powerful African Green Building Movement that is championing the growth of GB in their respective countries. Tanzania, Kenya, Ghana, Namibia, Mauritius, Botswana, Nigeria, Mozambique, Zambia, Zimbabwe, Ethiopia, and Uganda are among the countries that have joined the World Green Building Council and established their own Councils in their respective countries. Despite this affiliation, these countries' membership in the Council has had little impact in the development of sustainable housing in Africa (Windapo, 2014).

Green construction certification should be promoted and enforced by the relevant government wings. According to Qian and Chan (2010), countries with green legislation play an essential role in the GB Movement. The role of governments in supporting green construction is critical (Wu, 2022; Samari, 2012; Fei, 2021; Liu, 2022; Zhao, 2022; Alsanad, 2015), and proper policies and regulations should be put in place to assist GB growth. Even though educational programs were deemed the essential components in promoting and expediting efforts toward green and sustainable projects in Kuwait (Alsanad, 2015), other important aspects include defined laws and legislation. Sabiu (2020) states that laws and regulations of the government, reduced lifecycle cost, green building programs, protection of the environment and marketing were among the most important factors driving GB construction. In developed countries, GB construction has increased due to the rising number of building regulations and policies mandating energy-efficient structures. As a result, a market for environmentally friendly and energy-efficient materials for residential construction has emerged (Hafez, et al., 2023; Liu, 2021). When it comes to GB standards and policies, they cannot be looked at in isolation without considering government engagement in providing incentives to adhere to these policies.

Frost and Sullivan’s (2010) analysis of the South African green building market found that the market was still small but had great possibilities for growth. South Africa can boast of utilizing green building rating tools, as seen in the rating of several buildings. However, the local rating tools are not fully developed for the certification of buildings. Some African countries are using the Green Star rating tool from Australia and the American LEED system. The challenge in utilizing such tools is the lack of qualified assessors and documentation to capture the Life Cycle Cost (LCC) of the building materials. According to Mohammed (2016), the challenge in applying GBTs is the expenses of acquiring and running such tools and the lack of coordination and integration amongst the players in the building industry to assess green structures. Many African countries do not have GB legislation on which green rating tools can be applied, and many players in the building industry do not feel obliged to carry out their construction activities sustainably (Zulu, 2019; Agbajor · 2022; Liu, 2022; and Bungau, 2022; Koppa, et al., 2023).

2.8.1 The South African experience

South Africa is giant in Africa in the promotion of sustainability and GB development. The building industry contributed almost 83 billion rand (or nearly 5.4 billion dollars) to the nation's gross domestic product in 2020 (Galal, 2021; World Bank, 2018; Tendengu, et al., 2022). The country has had challenges in meeting its energy needs with load shedding extending for long hours. The South African power plants already in operation are beginning to struggle under the country's increasing energy demand (Akinbami, et al., 2021; Skillings and Lafford 2016). The nation has one of the best renewable energy strategies (Baker and Phillips, 2018) but little implementation of this strategy has taken place. Most South African structures, primarily those in the commercial, industrial, and institutional sectors, are energy-driven, while residential buildings, for example, account for 15 percent of the nation's total energy use (Agbajor, and Mewomo, 2022). According to a global analysis by Dodge Data and Analytics (2018), South Africa is one of the world's green construction marketplaces with one of the largest potentials for professional and technological growth (Jones and Mandyck, 2016). For instance, it was projected that by 2021, 48 percent of South African construction enterprises would have included green practices into their operations, up from 28 percent in 2018 (Dodge Data and Analytics, 2018).

However other studies have shown that South Africa and Botswana have a low use of GBTs and limited to commercial buildings (Venter et al., 2020). According to Smart Market Report (2016), client demand has always been a key component in their reports from 2008 to 2012, and interest in green construction activities has increased from 35 percent in 2012 to 40 percent in 2015. In the area of GBTs development the Green Building Council of South Africa (GBCSA), which was founded in 2007, sets the pace for the use of locally designed GB rating tools for the rest of Africa (Crafford, et al., 2017). The country has certified more green buildings (>600) than any African countries and is one of the few countries to have adopted a GBRT (Agbajor, and Mewomo, 2022). The Green Building Council of Australia created the Green Star SA rating tool which has been adopted in South Africa. It is thought to be appropriate because it considers a rating even if not all the credits are available for a project, making the scoring system adaptable.

The Green Star tool has been in use since 2009, it was launched by the GBCSA. The council can boast of 100 certifications since its inception as stated by Wilkinson, *"There are multiple incentives involved in green building initiatives, ultimately the upward trend in the number of buildings being certified and those applying for certification illustrates that awareness and perceptions around environmental issues have changed and evolved"* (GBCSA, publication, 2020). South Africa has a well-established legislative environment, related policies, and programs to advance sustainable development goals in the built environment sector, in accordance with the global trends (Agbajor, and Mewomo, 2022; Windapo, 2014: Kowet, and Ozumba, (2022). The construction sector of South African has created and accepted other industry-driven initiatives, such as EcoStandard that certifies construction products and materials, and the National Ecolabelling Program verifies environmental claims made by third parties (Shan and Hwang, 2018). Such a strategy disregards the economic, social, technical, and process-oriented aspects of sustainable development (Hill, et al., 2015). This is especially important in South Africa, where the National Environmental Management Act (107 of 1998) explicitly aims to achieve sustainable development. These and other recent laws and regulations adopted by the South African government expressly include the sustainability ethos. Additionally similar examples of this objective may be found in the National Housing Code (1999) and the Housing Act (Act No. 107 of 1997), both of which expressly say that the provision of housing should apply and uphold the principles of sustainable development (Hill, et al., 2015).

Despite all the effort by the industry to promote GBTs according to Agbajor, and Mewomo (2022) awareness of sustainability among the workers in the building industry was insufficient and the knowledge leaned towards environmental pillar of sustainability rather than the social or economic ones. Even though awareness is high among the professionals in the South African building industry, the utilization of GBTs has not grown as expected (Agbajor, and Mewomo, 2022; Windapo, 2014). According to Abdelkader, (2020) the perception of the construction workers is that they practice GB as merely a client request that must be met. These comments suggest that the way in which sustainability methods and concepts are seen by construction professionals may not be entirely favorable. Despite the country's achievement, the building industry is still a high contributor to global warming by the carbon dioxide emission (Oguntona et al., 2019; Gibberd, 2010; Crafford, et al., 2017 and Oguntona et al., 2019).

The other challenge in implementing green building projects in South Africa is higher upfront costs, expenditures related to green technologies and materials, and certification requirements for green buildings (Windapo, 2014; Simpeh et al., 2021). Authors like Isaksson and Linderoth, (2018), have mentioned socioeconomic inequality and the high cost of technology as being the two biggest obstacles to the country's widespread adoption and use of green construction. Information based on the construction professions, the factors hindering the use of GBTs in South Africa were inadequate data regarding the benefits of green buildings; inadequate cost data for greening existing buildings; limited sharing of knowledge regarding green practices; and inadequate information relative to current green building materials/products (Simpeh et al., 2021).

2.8.2 The development of Green Building Strategies in South Africa

South Africa heavily depend on the use of Green Star SA. The tool focuses on management, energy and water consumption, indoor environmental quality, and materials. The aspects of social, economic, and cultural values are not emphasized in the tool. However, both international and local materials have been considered and there is a wide array of consultation among the construction industry professionals, in terms of criteria to include in the tool. Under Green Star SA, there are nine key criteria for evaluation and include the project's site selection, design, and construction's impact on the environment. There are several credits for various projects that minimize a building's environmental impact in each of the nine categories. In a study by Zuo, et al., (2016) they found that Credits in the categories of Innovation, Ecology and Energy were relatively difficult to achieve.

The cost of certification could hinder the use of Green Star SA. As of 2009 the cost of submitting a green project ranged from R 36,000 to R160, 000. For low-cost housing development the current certification could be too high. Another issue with the rating tool is the lack of expertise among the contractors working on such green structures and in charge of providing training and information to the project team. Another difficulty identified was sourcing materials and managing documents. Flexibility is important for most African countries because of the lack of instruments to measure aspects like the LCC of building materials. However, the Green Star criteria of air quality and thermal and acoustic comfort may be difficult to measure for developing countries like Zambia.

Attempts have been made to develop other tools with their originality from South Africa like the SBAT (Sustainability Building Assessment Tool). When analyzing the achievement of South Africa in developing local tools, Gibberd (2005) asserted that SBAT had been designed to help encourage a responsive, integrated strategy for enhancing sustainability in buildings. It is especially applicable to scenarios in underdeveloped countries and is simple and affordable to utilize (Windapo, 2014). It evaluates green structures by assessing their performance concerning several social, economic, and environmental criteria. According to Gibberd (2005), the tool has been designed to be used in developing countries. It, therefore, includes aspects such as the influence of the building on the local economy. It can be used alongside more complex assessment tools and is not building type specific. Nevertheless, this technique only serves as a method for identifying problems and does not allow for the comprehensive examination of all sustainability features that are built into buildings (Kaatz et al., 2002). SBAT cannot be compared to the fully developed tools like LEED or BREEAM because it does not have the mechanism to measure the LCA and LCC of buildings. SBAT's results must be supplemented with other rating methods, making it expensive to employ, particularly in developing nations.

The South African experience shows that it is possible to adopt rating tools suitable to one’s environmental needs. The Green Star tool though adopted from the Australia was changed to carter for the South African needs. It has been stated that it has flows, in that it does not demonstrate the social, economic, geopolitical needs of the community which is an essential ingredient if sustainability is to be achieved. Community based sustainability goals must be set so that the full benefits are felt across the population. As stated earlier the challenge in South Africa is the sharing of resources across the social divide to achieve economic growth while sustaining the environment. The huge energy crises have brought to light the need to urgently look for solutions that will reduce the dependence on non-renewable energy sources. The use of the Green Star tool is achieving its intention of increasing the number of certified green buildings as it has risen from 100 to 300 in the last five years. However, the aim of increasing the knowledge and capacity of the profession to undertake certification has not been achieved fully. There is still poor perception and knowledge on the benefits of green certification both among the building professions as well as the public. A lot must be done to improve the attitude of the mass for the need to implement GB practices.

2.9 Utilization of Tools in Zambia

The Zambian building industry, like other Sub-Saharan African countries, has been growing fast. The construction industry in Zambia contributed 3,156 ZMK million to the country's GDP (CSO, 2020). Challenges of high utilization of resources (land, water, and energy) have come about due to the industry's growth. The increase in building activities has threatened the availability of arable land near the cities, and excessive use of water and energy on construction sites creating a scarcity of the commodity (Zulu, 2019; MLG, 2016; NHP, 2019). Some building practices have caused land degradation and the pollution of rivers and air.

Sustainability issues are high on the Zambian government's agenda, and it is a party to all treaties and agreements to reduce greenhouse gas emissions (Zulu, 2019; Chiwele et al., 2020). In Zambia, there is a need to fosters sustainable development as the economic sectors depend highly on raw materials. (Zulu, 2019; Chiwele et al., 2020). As a result, policies that assist in the long-term protection of natural resources have been prioritized. Sustainability policies and regulations are fragmented and found in isolated pieces of legislation, some of which are the environmental or the tourism policy (Aghimien et al., 2018; NHP, 2019). The use of renewable energy in buildings, comfort, safety, life cycle cost and the type of sustainable building materials is not addressed in the current policies (Aghimien et al., 2018; Zulu, 202019).

The utilization of GBTs has been influenced by several factors, including the demand for GBTs and the accessibility of tools on the market. In Zambia, there is very little publication on the utilization of various GBTs, and not a single GBT has officially been adopted for use. GBTs are a new practice in Zambia, with very few professionals having used any of them in their work (Aghimien et al., 2018; Zulu et al., 2022 and Oke et al. 2019). Awareness of GBTs is high in Zambia, but utilization is low, according to Oke et al. (2019, pg. 3249), who mentioned that *"there is an average level of awareness of SC practices among professionals; however, the level of implementation of these practices is* *low."* A developing country like Zambia can choose among the different GBTs available on the market or develop its own. The difficulty in obtaining GBTs from the market is that the cost of assessment may be too high, and property developers may not generate enough interest to pay for the evaluation. Exploring or developing GBTs that are available locally and are economical is an alternative. Another issue is the lack of knowledge among specialists about how to assess GB (William and Dair, 2016; Wu, 2019; Liu, 2022; Keleş et al., 2021; Saha, 2021).

Institutions of higher learning educate students on sustainable buildings, but there is a lack of practical training in GBTs, and as a result, few professionals can carry out an evaluation (Ayarkwa et al., 2022; Liu, 2022; Bungau, 2022). Green building assessment is costly due to the low number of assessors, and most evaluators are from outside the country. SHGs, which were developed to improve responsive and integrated approaches that can be utilized to develop more sustainable housing in Zambia, may accelerate the establishment of local GBTs. The guidelines seek to encourage home building that considers both global climate change obligations and local, sustainable development aspirations (MHID, 2016). SHGs can encourage sustainable building and awareness among housing sector stakeholders such as the government, built environment professionals, and end-users. The standards provide direction for designing more sustainable housing, as well as monitoring and evaluating how sustainability is integrated into housing (MHID, 2016). The procedures are not developed for scoring or rating housing but aid in planning and designing sustainable accommodation. Despite being launched in 2016, very few professionals use these guidelines or have heard about them. The challenge could be the lack of adequate information or the applicability of the guidelines in the day-to-day planning and construction of houses. The argument in the study is whether adopting the SHG is adequate to achieve green low-cost housing or other strategies are to be compared.

It is much easier to choose which rating tool to use if a country has resources; however, these GBTs are not affordable for most communities developing housing facilities. The cost of assessment has been one of the barriers to the utilization of tools, and most governments do not budget for assessment in their housing development (Dahle et al., 2016; Jarnehammar et al., 2008; Al Khalifa, 2019), particularly since the government is the biggest player in the construction of low-cost housing. Sharifi and Murayama (2013) have argued the importance of having assessment tools that are regionally specific or take into consideration adaptation to a locality. Gibson (2006) stated that this would mean that rating tools must be sensitive to those criteria that are key in enhancing and promoting specific environmental concerns. Different localities have different concerns that must be weighed up depending on the priority. As illustrated earlier, Zambia has a challenge of excessive use of biofuel and rating tools that point to an alternative source would be of great use compared to those that focus on reducing electrical energy for ventilation systems.

The buildings that were rated in Zambia did not use local tools, therefore the criteria weighting could be influenced by other geographical and climatic conditions. Mensah, 2019; Anshebo, 2022; and Guy, 2016) argued that building tools in different countries are developed according to the climatic conditions and the character of the communities. There is a drive by the professionals in the Zambian building industry to either develop a new tool or adopt an existing one. Zambia's new tool establishment would require resources that may not be available. Sharifi and Murayama (2013) stated that while each country should develop its own framework, this might not be possible due to various constraints. This is supported by Mpakati-Gama et. al., (2012), who compared the Green Star tool used in Australia and South Africa noted that in South Africa, there was slow progress in the use of the tool. This was exacerbated by the financial implications involved at various stages of the assessment and accreditation processes. In such situations, the adopted tool must be customized using suitable benchmarks and weightings based on a country's parameters.

The discourse brought forward that the current SHG should be further developed into a tool that can evaluate the performance of building activities and gauge their impact on the environment. The other challenge that was discussed is how the LCC of building materials could be dealt with in an environment where records are unavailable. The labelling of the LCC on materials should be tackled from various angles and should include the manufacturer's information right up to the developers and the Zambia Bureau of Standards must ensure all green building materials that enter a country have a LCC label on them.

2.10 Challenges in the Application of Green Building Strategies

GBTs demonstrate how much buildings impact the environment and how green building compliance can be measured and compared across different countries. However, GBTs have their own challenges; the market labelling of GB means that the strategies are only for the promotion of buildings by developers and governing councils without tenants getting the real benefit. Some studies have shown that without detailed knowledge of the credits or points that give the commercial or residential building a holistic green building rating, potential owners or occupants are in the dark when it comes to the sustainable benefits gained from planning and assessing a building (Bungau et al., 2022; Basten et al., 2019; Vitale et al., 2021). Some strategies lack a comprehensive though easy to read assessment resulting in the lack of uptake by the market (Yudelson, 2016; Schendler, 2010). Some GBTs may achieve a green rating level, but the real gain in energy or water efficiency may be lacking. Research in New Zealand on the Homestar Rating Tool determined that the claims of a GBC were not likely to be achieved in most dwellings (Ade & Rehm, 2019; Basten et al., 2019).

The exclusiveness of some rating tools inhibits utilization as it becomes too expensive to rate buildings. Some tools are developed for upmarket buildings or new buildings, leaving the existing stock with no assessment and opportunity to be made sustainable (Basten et al., 2019; and Vitale et al., 2021). Yudelson, (2016), stated that the method of the design and operation of rating tools inevitably leaves many buildings behind, restricting the tool's capability to impact the market. Some tool users believe that the instruments should be able to measure absolute performance goals rather than benchmarks or building codes. However, this may depend on the purpose of the assessment, and there may be a limitation to producing actual performance goals, especially in Africa where resources and information are scarce.

Many studies discussed the cost of certification, and several developers and tenants have emphasized the need to reduce GB's cost based on the evaluation. "*A fundamental hurdle to the implementation of many green building rating methods is a perceived increase in 'hard' construction costs and increased 'soft' expenses due to additional consultants and GBC certification fees,"* according to Ade and Rehm (2019, p. 199). The perceived cost is both in terms of certification fees and actual GBTs assessment. There is no market to take up that extra cost for going green (Sun, et al., 2019). Others have said LCAs incorporated in these tools require a lot of data. Collecting and updating the needed figures can involve substantial costs (Bragança et al., 2007 and Aspinal et al., 2012; Aje et al., 2015; and Oguntona et al., 2019).

It is argued that individual characteristics of each country, such as the climate and type of building stock necessitate a unique GBT for use and, to a great extent, varying assessment tools for different countries use diverse parameters (Assefa, et al., 2022; Reed, 2011). Bungau (2022) argued for the importance of having assessment tools that are region-specific or take into consideration adaptation to the locality. Liu (2022); Windapo 2014; Khani, 2021) stated that GBTs must be developed to suit those significant criteria to boost and enhance specific environmental concerns. Thus, different regions have different concerns that must be addressed. In describing some assessment tools, Reed (2009, p. 674) states that *"they are not universally applicable and assessment methods need to be implemented in a much wider array of categories to foster true environmental protection."*

Although LEED and BREEAM are widely used, critics have argued that these tools have their shortcomings and include the absence of important criteria such as social and economic sustainability, and they lack a mechanism for local adaptability and participation (Sharifi et al., (2013) and Murray et al., (2017). Others say the tools lack social and cultural criteria (Khani, 2021 and Lui, 2022). The increased number of tools being developed indicates a need that has to be filled to achieve the green building aspirations of many regions, and no single GBRT can accomplish that. Most sustainable building standards and methodologies that have been developed worldwide are more focused on evaluating the environmental performance of buildings instead of incorporating the environmental and social and economic aspects of sustainability and their interdependencies (Isa et al., 2014; Liu et al., 2022; Bungau et al., 2022). Khani (2021).

According to Abu Hassan et al, and Cheen (2013), assessment tools have been developed with different evaluation criteria based on conditions to suit the characteristics of the countries for which the tools are designed. Tools developed in Europe, or the United States typically rely on regional building product information, which would need to be replaced by a native counterpart if transferred elsewhere. One of the issues related to transferring these tools to new contexts is whether extensive and reliable data on building materials and components are available (Herda, 2017; Mayhoub, 2021; Cao, 2022). The most recognized tools, such as the LEED or the BREAM system, may be too complicated for the scale of the Zambian building industry. Zambia needs a system that matches the level and scale of building development. That tool needs to be simple enough to be used by building professions at any level yet incorporate and uphold best practices in GB development. In his study, Cole (2005, p.27) also stated that *"an assessment method that is applicable in one country may not be applied in another, the importance given to energy, water, economy, geographical features, resource consumption, government policies, cultural value and public awareness associated with systems design is different across regions."* Consequently, if a system specific to one country is used in another, the assessment results may not reflect the realistic performance of a building. Another argument is that GBTs consider the location and climate as important factors thus, there is not one tool that is suitable for all countries (Reed, et.al., 2009.; Ali, and Nsairat, 2009; Khan, 2021; Marchi et al., 2021, Anshebo et al., 2022). According to Kowet and Aghaegbuna (2022) the research respondents emphasized the extra documentation needed for green building, would call for more expertise and resources.

According to Ogunsanmi et.al., (2013) who investigated the awareness of GB among professionals in the building industry (Site Engineers, Lectures, Architects, Quantity Surveyors and NSE- Technicians, Construction Managers, Project Managers, Site Managers and Facility Managers) showed that 84 percent of respondents believed that environmental and resource conservation (energy conservation, health and safety and water conservation) was the most perceived green building concept to adopt. In Abolore (2012), most of the respondents (builders, civil engineers, architects, planners, estate surveyors, and valuers) with 15-19 years of experience believed that the environmental aspect of sustainability is critical, with social and economic aspects of construction receiving little attention. Energy efficiency, water conservation, building and environment management, indoor air, health and comfort, and material resources should have high rates according to Berawi et al., (2019). It may be determined that when it comes to choosing criteria for evaluating buildings, most construction professionals would prefer environmental factors over social or economic criteria.

This preference for environmental over social and economic criteria negatively impacts the quality of GB since social and economic criteria add value to buildings by addressing the physical and mental well-being of tenants. One explanation for the poor selection of social and economic criteria could be a lack of understanding of how this category affects building sustainability. As stated by Kaatz et al. (2007, pp. 444), *"It seems that the social, cultural and economic dimensions of sustainable construction are more difficult to tackle and operationalize in construction because they often provide intangible and unquantifiable benefits, such as personal fulfilment and the sense of ownership and control."* However, the proposed tool considered both environmental, social, and economic criteria.

Energy efficiency, water conservation, building and environment management, indoor air, health and comfort, and material resources should have high rates, according to Berawi et al., (2019). This is supported by Aquino et al., (2019, p. 5) who noted that, *"energy efficiency is the most important green building indicator for engineers and end-users, while water efficiency is the most important parameter for architects and sustainability for urban planners."* This shows that preference on which criteria to rate highly is subject to the different users of tools.

In the quest to develop an assessment tool for Zambian green housing, factors of integrating environmental, social, economic, and local adaptation were key. Therefore, CASSUD was adopted as the best framework to develop a GBTs because it included key components like the building form; environmental; society; economics; site/ land uses; communication; and transportation criteria. However, not every component in the existing tools was considered in the proposed tool. Some parameters were difficult to attain, for example, calculating the life cycle cost of green structures. In an environment where information is scarce and most imported green products are not correctly labelled, the process might be lengthy and costly. As highlighted by Bjorn et al. (2013, p. 812), *"little has been done concerning life cycle assessment (LCA) in Africa, where networks/research groups are notably limited."* There is a very poor inventory of the life cycle cost of imported green materials, including locally produced ones in most developing countries. Many green commodities entering the country lack specific labelling, making it impossible to keep track of the life cycle profile. Apart from the difficulty of labelling green goods, the cost of shipping is overlooked. According to Fithian and Sheets (2017), in labelling green materials issues of distance from which materials are collected or toxins that they may emit into the air are usually ignored. Due to the limits discussed above the calculation of the LCC in most of the green materials studied was overlooked.

2.11 Factors Associated with the Utilization of Tools.

Several factors are associated with the use of GBTs; The existence of GBTs, government and private-sector incentives, strong government leadership, an expansion of state and local green building programs, and advances in green building technology (Dahle et al., 2016; Marsh et al., 2021; Saha et al., 2021 AlSanad, 2015, Zulu et al., 2022). Increased community knowledge and experience in rating tools may accelerate the use of GB tools. Sometimes tools are used because the users are interested in sustainability issues, or it could be a push due to statutory obligations. Constraints to green building compliance include the failure of the market to attract the clients to go green and lack of resources available in a project sponsorship from developers (Saha et al., 2021; Bungau et al., 2022; Liu et al., 2022). The other factors could be due to poor resource use and a lack of knowledge on using available resources to develop sustainable structures (AlSanad, 2015; Bungau et al., 2022; Liu et al., 2022; Dahle et al., 2016).

According to Huang et. al., (2018) and Assadiki et al; (2022) the factors associated with GBTs include government involvement, the cost and benefits, experience in managing GB and knowledge of the benefits of applying green building strategies. When there is no political will or poor policies to support green building development, politics comes in the way of GB attainment (Kamranfar, et al., 2022). The government's lack of involvement in GB may contribute to low utilization in the Zambian building industry. Governments are the biggest clients in the promotion of GB (Qian and Chan, 2010; Atsusaka, 2003; Samari, 2012; Sutherland, 1991; Golove et al., 1996; Varone et al., 2000; Ofori, 2006), and if they champion GB projects, this could influence other players to join. However, Oyalowo, (2016) stated that stringent regulations could be a factor if the process needed to implement them takes a long time. According to Alsanad (2015), governments play a critical role in promoting green construction. By virtue of their size, government entities have more opportunities to invest in green projects and hence have a higher impact on communities than the private sector. Even though government is developing policies and regulations for GBTs their involvement has been low in most developed countries (Zulu et al., 2019; Aghimien et al., 2018; Windapo, 2016). They are the biggest clients in the building industry thus they should be in the forefront of supporting programmes that encourage the rating of buildings (Fisher et al., 1989; Sutherland, 1991; Golove et al., 1996; Varone et al., 2000; Ofori, 2006; and Alsanad, 2015). As Djokovic et al. (2014, pp. 140) state that, *"there must be a sustainable construction policy that indicates when, how and who enforces what."*

The lack of knowledge about the benefits of GB has a negative association with the utilization of GBTs, according to Hu et al., 2014. When little is known about the profits of GB, it is associated with low use of rating tools. The lack of knowledge about GB is seen in both building professionals and users of the buildings (Assadiki et al; 2022; Huang, 2018; Liu et al., 2022; Darko et al., 2017). Although the knowledge levels differ, these two groups influence each other in using tools. Hobman and Frederiks (2014) concluded in their study that one of the main reasons for poor utilization of tools was limited knowledge, awareness, and unavailability of green energy programs. Others like Chan et al. (2018) and Hwang et al. (2012) linked knowledge and awareness as variables that drive interest in and demand for sustainable green construction.

Based on Simpeh and Smallwood (2021), the lack of incentives for promoting GB, inadequate cost data, and insufficient information about the financial and economic benefits and potential of rating structures contribute to the low development of sustainable buildings. As Qian and Chan (2010, pp.13) state that, *"Government's role is to offer financial support directly or indirectly to socially and environmentally preferred BEE options through investment incentives and low-cost loans, and special funding for BEE programmers."* Clients and developers always look out for incentives to be engaged in a cause and financial benefits drive consumers to be engaged in GB. If they can prove that GB is going to attract more clients and the investment is worth tapping money into, the level of utilization of GBTs may increase. The application of GBTs is associated with its cost, as seen by Simpeh and Smallwood (2021); and Assefa et al., (2022). Many customers will be eager to engage in sustainable structures if the long-term financial rewards are quantified, thereby boosting the use of GBTs. It is thought that tenant demand and the financial benefits and corporate social responsibility motivate the utilization of GBTs (Liu et al., 2022).

Pitroda and Bhatt (2017) pointed out the importance of environmental, social, economic, political, cultural, and technical factors. The economic benefits include the reduced cost of developing GBTs, financial support, and foreign direct investment (FDI) (Matisoff et al., 2016, Smit, and Du Toit, 2015 Alaloul, et al., (2022). Because the initial cost of developing sustainable structures is high, many inventors seek financial backing from either the government or lending institutions.

In other research, the lack of government rules or regulations was not the top factor, but the concern of greater investment expenses was (Ametepey et al., 2015; Kibert, 2012; Häkkinen and Belloni, 2014; and Aghimien et al., 2018). Authors such as Aigbavboa et al. (2017) argue that the high premium placed on sustainability construction (SC) is not looked at in its entirety because the long-term cost is decreased due to the life-cycle cost savings. The factors of sustainable construction, as per Onososen et al. (2019), were awareness of resource conservation, government policy rules, financial incentives, client requirements, lower long-term costs, and urban planning policies. *"Rising energy prices, tenant demand, availability of the industry (Green Star) grading system, competitive advantage, and company image were significant factors of adopting green building concepts into the project,"* according to Windapo (2014, p. 6096). The involvement of consumers and developers in pushing for sustainable housing is a big factor of sustainability.

Government involvement in promoting sustainable housing has also been a big factor toward GBTs. Oguntona et al., (2019) showed that the top factors of GB project implementation included the availability of finance options, a better market for green products/materials, knowledge and training on GB technologies, incentives, and the affordability of GB materials. Rather than concentrating on reducing the cost of assessment, Oguntona et. al., (2019) discussed other options like the availability of more finance from governments and Non-governmental Organizations. Lee et al. (2013) proposed a funding approach that included a government guarantee for GB projects based on Certified Emission Reductions (CER). In their model, the government guarantees to support financing of a GB project in return for CER. The government may offer tax exemptions on green materials or carbon emission tax. Branker and Pearce (2010) emphasized the need for government assistance in green construction financing, citing the government's pledge to share the project's default risk with the private sector as an example.

Others have grouped factors into financial and political constraints, the lack of building codes, regulations, awareness, and knowledge (Zulu et al., 2019; Ametepey et al., 2015;

Darko et al., 2017). According to CIB Report, (1999), the lack of capacity in the construction sector to implement sustainable practices is a factor. William et al., (2016) identified lack of knowledge, understanding, and information as the major factors to the delivery of sustainable structures. Even Alsand (2015) stated that a lack of awareness was the main obstacle to the adoption of sustainable construction practices. According to Assylbekov et al., (2021) and Windapo (2014), poor use of tools is due to a lack of skills or experience to undertake GB assessment.

The high cost of GBTs and certification has been considered as a very important factor in attaining sustainable structures, as seen in (Liu et al., 2022; Bungau et al., 2022) where the fear of higher investment expenses for sustainable buildings compared with traditional buildings and the risks of unforeseen costs are often addressed as factors for sustainable buildings. Other studies have shown that cost was a major factor. A similar study was undertaken in Zambia by Aghimien et al., (2018), and who found that the fear of higher investment costs was the highest factor to sustainable construction, this was also seen in Häkkinen and Belloni, (2011) and Djokoto et al., (2014). According to Oyalowo (2016), most respondents, 68 percent, believed that the cost of construction is a factor in the adoption of sustainable building practices. Institutional investors engaged in the green estate market will aid in injecting liquidity and allow primary lenders to make available capital to develop new green lending products (World Bank, 2018).

Ntshwene et al., (2014) mentioned that the respondents in their study considered marketing potential and increased rent to be important benefits of GB and healthy indoor air quality to be the least important. Other factors were green technology and techniques, reliability and quality of the specification, leadership, responsibility, stakeholder involvement and benchmarking systems (Lam et al., 2010; Malanca, 2010; Mpakati-Gama et al., 2011; Serpell, 2013). The factors associated with the use of GBTs have been summarized in Table 2:1.

Table 2-1: The factors associated with the use of GBTS.

Code	Author	Factor associated with the use of GBTS
B1	Mangialardo et al., 2019; Wang et al. (2016); Ghazilla et al., (2015); Ametepey et al., (2015); Liu et al.,(2022); Bungau et al., (2022); Liu et al., (2022); and Bungau et al., (2022)	**Financial constraints** • Lack of funding and support from the private sector • High initial cost of green. Lack of financial resources technologies and systems
B2	Ametepey et al., (2015); Ali et al., (2016)	• Lack of availability of environmentally sustainable materials and products Inefficient technology
B3	Bohari et al., 2016; Wang et al., (2016); Timilsina et al., (2016); Ali et al., (2016); Zulu et al., 2019; Ahn et al., (2013); Persson and Grönkvist (2015); Ghazilla et al., (2015); Azad & Akbar (2015); Attaran & Celik (2015); Ametepey et al., (2015); AlSanad (2015).	• Low level awareness & knowledge of green building techniques
B4	Persson & Grönkvist, 2015; Alsanad (2015); Darko et al., (2017); Dadzie & Ohemeng (2014); Hikmat et al., (2009); Zulu et al., 2019; Ametepey et al., 2015; and Darko et al., (2017)	• Lack of policy and building codes • Lack of national standards for sustainable building materials
B5	Samari et al., (2013); Ametepey et al., (2015); Azad & Akbar (2015); AlSanad (2015); Persson & Grönkvist (2015); Ghazilla et al., (2015); Ali et al., (2016); Timilsina et al., (2016), Wang et al., (2016).	• Lack of incentives from government
B6	Zhang & Wang, (2013); Mosly, (2015); Ametepey et al., (2015); AlSanad, (2015); Akadiri, (2015); Ali et al., (2016); Kasai & Jabbour, (2014); Persson & Grönkvist, (2015); Azad & Akbar, (2015); and (Wang et al., 2018)	• Cultural and market • Weak market demand

2.11.1 The parameters for green building rating tools development

GB technology and the basis on which structures are considered sustainable has evolved over the last century. The 21st-century challenges of high demand for energy and the effect of greenhouse gases on the atmosphere pushed the agenda to develop energy-efficient buildings (Gielen et al., 2019; Lamb, et al., 2021). The parameters that make buildings green have also broadened to include social, economic, and cultural sustainability (Liu et al., 2022; Vierra, S. 2022). Kaatz et al., (2005, p. 441) stated that *"rating tools should be developed with integration, transparency, and accessibility in mind. These will result in an effective and content relevant assessment."* They further argue that an effective rating tool should facilitate change in the culture of building practice, the market for the demand for such structures, and facilitate capacity building of stakeholders (Kaatz et al., 2005). According to Kibert (2013), the goal of sustainable construction is to create and operate a healthy built environment based on resource efficiency and ecological design with an emphasis on seven core Principles across the building's life cycle:

i. reducing resource consumption;
ii. reusing resources;
iii. using recycled resources;
iv. protecting nature;
v. eliminating toxins; and
vi. applying life cycle costing and focusing on quality.

GBTs measure the sustainability of a building based on the above principles being considered. The school of thought in this study is that the life cycle measurement of buildings is not enough to bring about sustainable buildings. Thus, it is important to incorporate other social, economic, and cultural sustainability criteria.

The first-generation tools were too specific to counter the life cycle challenges of energy and materials structure. They measured the product rather than outlining the measures necessary to reduce the negative effect of the buildings. Instead of weights premised on relevant criteria subject to site conditions and the beneficial influence on the environment, the tools were built with a defined and precise weighting that the buildings were to follow (Cole, 2013; Kshirsagar, 2015). According to Cole (2013), the instruments were stiff and could not be changed for different environmental conditions or a region's economic situation. Instead of a fixed weighting, the tools should be flexible enough to show a feasible building alteration to meet compliance.

The second generation of tools was broader and more laborious, as they included performance indicators like LCA approaches (Chehrzad et al., (2016). The current tools are being changed so that they are market-based with a performance threshold in developing sustainable buildings. Evaluation instruments have progressed over the years, with each region and country developing its own (Anshebo et al., 2022; Cao et al., 2022). This growth has resulted from differences in environment, climate, policies, and standards. The expansion of the tools is constantly evolving due to the changing demands of society (Wen et al., 2020).

2.11.2 Examples of green building rating tools

Several certification systems have been developed answering to the various sustainability needs of different countries. Some tools are building-specific, while others cater for different environmental challenges on construction sites (Cao et al., 2022; Fu et al., 2021). Comparison of the tools helps to distinguish them and, at the same time, highlights any shortcoming inherent in them. The comparison of the tools may be the starting point for developing new ones suitable for Zambia. The rating tools, such as BREEAM, LEED, CASBEE, Green Star South Africa, and DGNB were compared based on their market prominence.

2.11.3 BREEAM tool

BREEAM was launched in 1989 in the United Kingdom. It is the oldest building assessment system, and many other rating systems use its framework (Ade, and Rehm 2019)) As shown in Table 2.2, BREEAM splits assessment into ten categories, each containing multiple parameters with pre-weighted credits that can be cumulative or based on performance against specific criteria such as Standard Assessment Procedure (Kshirsagar et al., 2015). The BREEAM tool evaluates a building by awarding an assessment weight for each criterion (Ade and Rehm, 2019). Despite being the first tool created, BREEAM has not performed as well as LEED. The LEED might have become more well-known than the BREEAM through publicity and advertising. Although the weighting for energy and health and wellbeing in BREEAM is the same as in LEED and Green Star, in other tools energy has the largest weight.

The criteria selection process is quite similar to LEED and Green Star. Like LEED and Green Star, BREEAM emphasizes innovation, although its weighting is substantially higher. While there is a significant disparity between energy and the other criteria in LEED and Green Star, the energy weight in BREEAM is close to the other criteria.

Table 2-2: BREEAM rating tool

Environmental section	Weighting
Management	12%
Health and Wellbeing	15%
Energy	15%
Transport	9%
Water	7%
Materials	13.5%
Waste	8.5%
Land Use and Ecology	10%
Pollution	10%
Total	100%
Innovation (additional)	10%
Maximum	110%

BREEAM®

Pass	Good	Very good	Excellent	Outstanding
30 – 45%	45 – 55%	55 – 70%	70 – 85%	85 – 100%

(After, Sachs, 2016)

The challenge with BREEAM is that the assessment must involve a committed site team that has to give feedback to the assessors as to the measures taken to achieve the requirement of BREEAM. If the team is not committed this can cause delay in certification and the achievement of the rating. There should also be a project manager or lead person who can articulate the goals and necessity of reaching the project's desired BREEAM rating. Since BREEAM assessors generally lack the power to pressure the project team to work toward satisfying the BREEAM standards, it is highly challenging for them to carry out the evaluation without any assistance from the project manager or team leader who will apply the green standards required in BREEAM. The challenge in the third world of carrying out a BREEAM rating is that most project managers are not familiar with green buildings and so trying to achieve the parameters may take long and the certification can be delayed. Knowledge about these tools should increase in countries like Zambia if BREEAM certification is to be achievable.

2.11.4 LEED tool

LEED tool was developed in 1998 by the United States Green Building Council (USGBC). It is used as a design guideline and third-party certification tool, and it aims to improve tenant satisfaction, environmental performance, and economic benefits of buildings. Komurlu et al., (2015), commenting on LEED, have stated that it is the most widely used tool, and other tools are established using its framework. It is based on a set of prerequisites and credits. There are points for each criterion as follows; sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation and design process (Yamany et al., 2016). These criteria get points each, while the parameter for energy get more points, as shown in Table 2.3.

Table 2-3: LEED rating tool

Environmental section	Points
Sustainable sites	26
Water efficiency	10
Energy and Athmosphere	35
Materials and Resources	14
Indoor environmental Quality	15
Total	100
Innovation and design process	6
Regional Priority	4
Maximum	110

Certified	Silver	Gold	Platinum
≤ 49 p.	≤ 59 p.	≤ 79 p.	≥ 80 p.

(After: Sachs, 2016)

Altogether, the LEED system has 110 points divided into the category of certification (≤ 49- ≥80 points), from certified to platinum. Credits are awarded based on compliance with a set of standardized and measurable criteria (Yamany et al., 2016). All prerequisites must be achieved to qualify for certification, and points add up to a final score.

The LEED certification requires all documentation to be available to meet the minimum certification requirement. All the information is made available by the project team. They must set well in advance before the building is constructed what innovation they will implement to meet the desired certification. The USGBC will process the information and submit it for final assessment, and notification will be given once the project has been certified (Komurlu et al., 2015).

The LEED tool's challenge is the level at which the requirement for certification is so stringent, making it difficult to use in developing countries like Zambia. Smith et al. (2006) expressed that LEED is a more complex and largely paper-based system. It remains more extensive and requires expert knowledge to use or be part of an assessment team.

2.11.5 Green Star

Green Star is an Australian environmental rating system launched in 2003 and developed by the Green Building Council of Australia (GBCA, 2015). It was developed with its origin from the LEED system and was meant to cater for hotter climates that require cooling systems and solar shading. The rating tool is designed to reduce greenhouse gas emissions by 62 percent, power consumption by 66 percent, portable water usage by 51 percent, and construction and demolition waste recycling by 96 percent. Depending on the scores gained for a building, the Green Star credit system is based on the following levels: 1-3 Stars (10–44 points); 4 Stars (45–59 points); 5 Stars (60–74 points); 6 Stars (75+ points) (GBCA, 2015; Tang et al., 2022). The Green Star earns 148 points when paired with innovation, as shown in Table 2.4.

Table 2-4: Green Star rating tool

Environmental section	Points
Management	12
Indoor Environment Quality	27
Energy	29
Transport	11
Water	12
Materials	25
Land Use and Ecology	8
Emission	19
Total	143
Innovation (additional)	5
Maximum	148

GREEN BUILDING COUNCIL
OF SOUTH AFRICA

4 star	5 star	6 star
45 - 59 p.	60 - 74 p.	75 - 100 p.

(After Sachs, 2016)

The Green Star rating system is recognized as the most appropriate tool for Southern Africa due to the similarities in weather patterns. However, the tool may not be practical because it includes efficient monitoring of HVAC systems and, as well as the measurement of greenhouse emissions, which might not be feasible in developing countries. The social-economic processes differ significantly as well. Tang et al., (2022) outlined the opportunities and complexities of gaining a Green Star rating. The tool is used as a compliance tool rather than a tool to encourage environmental innovation. Henri (2009) outlined the certification process as being very complex, with the need for approximately 150 pieces of separate documentary evidence to fulfil Green Star accreditation requirements for a five-star building. Despite these complexes, it has penetrated the Southern African region with its use in South Africa and Kenya.

2.11.6 DGNB rating tool

The ecological quality, life cycle assessment, primary energy requirement, threats to the local environment, and land usage are all part of the DGNB evaluation framework, as shown in Table 2.5. The building's economic quality is determined by the structure's life-cycle costs, conversion feasibility, and marketability (Hamedani & Huber, 2010; Ade et al., 2020).

Table 2-5: DGNB rating tool

Environmental section	Weighting
Ecological quality	22,5%
Economical quality	22,5%
Sociocultural quality	22,5%
Technical quality	22,5%
Process quality	10%
Total	100%
Site quality	0%
Maximum	100%

	Bronze*	Silver	Gold	Platinum
Minimum	-	35%	50%	65%
Total	35 - 50%	50 – 65%	65 – 80%	80 – 100%

(After Sachs, 2016)

The socio-cultural and functional quality of buildings includes thermal, visual, and acoustical comfort, outdoor space qualities and the efficient use of space. The availability and designs of the buildings are also assessed. From a technical perspective, it includes fire prevention, sound insulation and the suitability for dismantling and recycling (Ade et al., 2020). According to Cottrell, (2015), the building structure's heat and water content protection quality and maintenance count as extremely significant criteria.

The DGNB tool stands out because it uses special standards that are not found in other tools. Then the tool's weighting of the criteria is generally similar, and it lacks the innovation or regional priority criteria that can be found in other tools. The challenge with DGNB is the complexity of the criteria which must be interpreted by project leaders on site and brings together different specialization in answering the criteria requirement. If the leaders have little knowledge about the tool, it delays certification. According to Møller, et al., (2018) one of the largest barriers to the use of DGNB is the complexity and understanding of the base material. Team leaders are asked to provide a Statement Importance percentage for each of the provided statements within the five DGNB Topics that should amount to a total 100%. This requires a lot of time which might be difficult to do on a busy site.

2.11.7 CASBEE tool

The Environmental Assessment Method (CASBEE) was developed by The Japanese Sustainable Building Consortium (JSBC). It assesses the quality of a building based on building materials and equipment that have a little environmental impact and includes the level of internal comfort (Miyazaki, 2019; Banani, 2011).

CASBEE criteria are based on two main categories shown in Figure 2.5: (Q) Building Environmental Quality and Performance and (LR) Reduction of Building

Environment Loading. As shown in CASBEE (2015) report, the system assesses a building project using a scale called building environmental efficiency (BEE), which is given by the ratio between the two measurements, built environmental quality(Q) and built environment load (LR) BEE=Q/ LR.

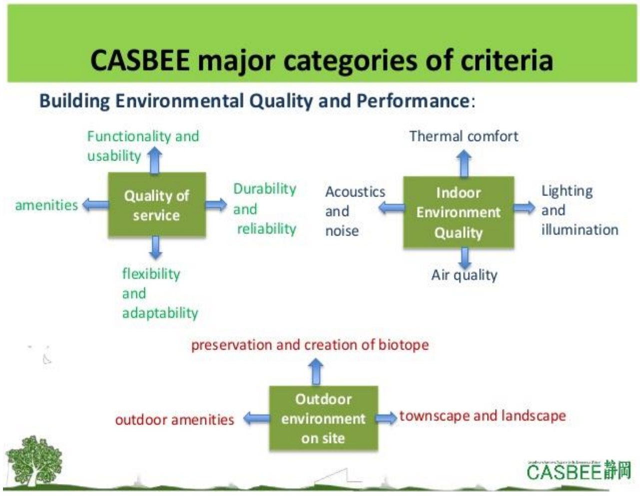


Figure 2-5: CASBEE categories

(After CASBEE, 2017)

Distinct scores for (Q) and (LR) are utilized to compute BEE, with higher marks aiming to improve load reduction quality and quality performance. The assessment elements in Q (building environmental quality) and L (building environmental load) should be based on the scoring standards established for each level (levels 1-5) (Miyazaki, 2019; Banani 2011; CASBEE, 2015). The points for each item are assigned as 1 point for level 1 to 5 points for level 5 as illustrated in Table 2.6.

Table 2-6: CASBEE assessment criteria

Assessment fields	Recategorized	Subcategories	BEE
Energy efficency	Q for Quality and L for Load	Q1 Indoor environment	Numerator
		Q2 Quality of service	
Resource efficiency		Q3 Outdoor environment	
Local environment		L1 Energy	Denominator
		L2 Resources and materials	
Indoor environment		L3 Off-site environment	

Poor (C)	Slightly poor (B-)	Good (B+)	Very good (A)	Superior (S)
≤ 0.5 BEE	≤ 1.0 BEE	≤ 1.5 BEE	≤ 3.0 BEE	≥ 3.0 BEE

(After Sachs, 2016)

The tool assesses superior buildings and is largely y focused on Japan or Asia. It appears unsuitable for other regions based on its regionalization. CASBEE evaluates the connection between the building and the environment differently than other rating systems. Because of the difference it's difficult to compare the assessment with other tools.

2.11.8 SBAT rating system

The Sustainable Building Assessment Tool (SBAT) was developed in 2002 by the Council for Scientific and Industrial Research (CSIR). The tool is meant to be a decision support tool for building design teams (Gibberd, 2005; Koppa, 2023). The tool assesses the performance of a building with respect to several social-economic and environmental criteria. Gibberd (2005) mentioned that SBAT is not building specific but looks at a variety of structures such as offices, factories, schools, clinics, and housing.

The social aspect observes occupant comfort, inclusive environments, access to facilities, participation, and control issues. Inclusiveness of all people in buildings, especially the disabled, is key to attaining accessibility. Education, health, and safety criteria are considered in the tool, where the building facilities give opportunities for students to access information through the internet. Access to public buildings, both internal and external, is one of the safety criteria. The economic sustainability criterion promotes local expertise, building material supply, local component manufacturer, outsourcing options, and repairs and maintenance. The ongoing cost of buildings is included in the tool and covers maintenance, cleaning, security, and insurance.

Environmental issues include the reduction of water consumption through rainwater harvesting, greywater use, collection of runoff water and planting around the buildings. Site selection and material used are also cardinal in the evaluation.

The energy component supports energy conservation and alternate power use. It analyzes material reuse and recycling and encompasses artificial and passive ventilation, heating, cooling, and energy-efficient fittings and equipment. As demonstrated in Figure 2.6, the SBAT building assessment method takes all 15 locations in a building multiplied by the five (5) criteria, yielding 75 indicators.

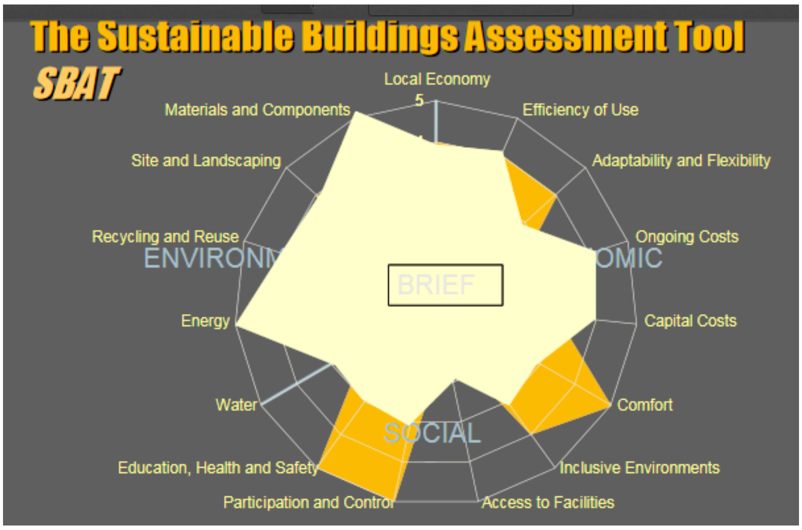


Figure 2-6: SBAT tool criteria

(After Gibberd, 2002)

Kaatz et al., (2007), commenting on SBAT, stated that the tool operates as a problem-identification method and does not provide a detailed assessment of the full range of sustainability dimensions inherent in buildings.

Unlike the Green Star or LEED, SBAT does not have credit points and thus cannot be used for certification. The assessment criteria are used to compare the tool against other tools. Because it was created for the Southern African region, it is being considered for usage in Zambia. It is the region's first tool developed to consider sustainability from three perspectives: environmental and social and economic.

2.12 The Sustainability Housing Guidelines

The SHGs were established in 2016 under the hospice of the MLGH in Zambia. The guidelines introduce sustainability and demonstrate how it is integrated into housing. It provides a comprehensive introduction to approaches and technologies that can be used to improve the sustainability performance of the built environment (MLGH, 2016;). The strategies in the document can be used by developers who want to incorporate sustainability in their housing development. It introduces aspects of GB by following various design criteria to tackle the efficient use of energy and resources with Sustainability Integration Processes (SIP). SIP supports housing development at different building life cycle stages to ensure that sustainability is considered and integrated into building construction with 17 criteria.

The SHGs are one of the few documents considering social and economic factors in attaining GB (MLGH, 2016). There is no assessment mechanism; hence, SHGs cannot be used to rate structures. The guidelines' day-to-day applicability is unknown, and only a few professionals are familiar with it for the developing GB.

2.12.1 Comparative literature review of selected green building rating tools

Comparison of different rating tools has been going on for a long time and assessing the performance of the rating tools has helped to develop new tools that have better performance. Liu et. al., (2019) stated that side-by-side comparisons of different rating tools generate applicable methods in countries keen to develop new assessment tools.

The consideration in the research focused on knowledge-based tools because the aim was to increase knowledge of green building strategies. This broad spectrum of assessment would enable both professionals and non-professionals to utilize it. The research did not adopt any of the certification of the tools but only considered their criteria. Several studies have used comparative literature review when selecting a specific rating tool for use (Hikmat & Nsairat, 2009; Fenner, 2007; and Bernardi et al., 2017; Liu et. al., (2019); Luangcharoenrat and Intrachooto (2019); Gale (2011); Nguyen (2011); Illankoon et al., (2019); and Bahaudin et al., (2014). The analysis allows for a fair selection of criteria and compares similar parameters. Hikmat and Nsairat (2009) compared tools such as LEED, CASBEE, BREEAM, GB Tool and others to define new assessment items in respect of conditions local to Jordan. After selecting the assessment items, the AHP method was used to weigh the preferred criteria. This method of selection was used in most comparative studies. The method was adopted in this study whilst capitalizing on secondary sources of information such as the internet and e-books.

Nguyen and Altan (2011) mentioned several levels at which assessment tools are compared. In some studies, they used a four-level assessment method comparison, including:

i. General comparison;
ii. Category comparison;
iii. Criterion comparison; and
iv. Indicator comparison.

To make comparisons, the tools must have similar characteristics, which would allow for a non-biased assessment. The comparative literature review focused on the similarities and differences in the tools in terms of cost, the number of certifications of GB, and the type of criteria for assessment. Because of the available evidence from other studies, the comparison aided in identifying similarities, differences, and limitations in the existing tools and that was the basis on which a GB assessment tool could be developed. Comparative review studies used a variety of assessment tools to draw parallels, some of which were qualitative, quantitative, or both (Kshirsagar et al., 2015). The tools' choice was based on the literature reviewed and included: BREEAM; LEED; CASBEE; Green Star; DGNB; SBAT tools; and SHG. A comparison was also seen between Green Star Australia and South Africa (Appendix H).

2.12.2 Rationale for comparing tools

A comparative literature review is used to define and demonstrate relationships between two or more variables by observing different situations or strategies and investigating the similarities and distinctions to understand the underlying reasons (Boru, 2018; DanieL, 2016). In this study, a comparative literature review was conducted to uncover similarities and variations in assessment tools, as well as the reasons for those discrepancies and how they might affect the ultimate purpose of designing local assessment tools. According to Boru, (2018) a comparative literature review is conducted so that relationships are established between or among the variables or to distinguish their characters for selecting those ideal parameters. A significant body of knowledge exists on the comparison of GBTS, where the association was made on scopes, features, structure, strengths, and weaknesses (Hikmat & Nsairat, 2009; Fenner, 2007; and Bernardi et al., 2017; Awadh, 2017; Boru, 2018; Daniel et al., 2016; Valdebenito, 2013; Hamedani & Huber, 2012; Doan, et al., 2017). Comparison explains the similarities and differences in groups or processes using the same measure or design. Daniel et al., (2016) mentioned that comparative review allows users to choose the structure, performance assessment methods, category weighting, and documentation requirements for certification character.

Having looked at South Africa as an example from which lessons can be drawn SBAT tool was included in the study. Because it's a tool developed within the region it is hoped that the parameters of measurement would be similar. In choosing which assessment tools to compare studies like Doan et al., (2017), Boru, (2018), Nguyen (2011), Nasser et al., (2017); Daniel et al., (2016); Boru, (2018); Nguyen, (2011); and Snyder, (2019) influenced the selection. Table 2.7 below summarizes the parameters and criteria comparison.

The comparative study in this research focused on environmental, social, and economic criteria differences as seen in studies by Hikmat & Nsairat, 2009; Fenner, 2007; and Bernardi et al., 2017; Liu et. al., (2019); Luangcharoenrat and Intrachooto (2019); Gale (2011); Nguyen (2011); Illankoon et al., (2019); and Bahaudin et al., (2014). It involved a descriptive comparison, where differences and similarities in methodology and criteria were given in detail for the selected GBTs. The aim was not to generate changes but to identify strengths and appropriateness for use relevant to the study.

Table 2-7: Summary of comparative study

S/No.	Comparative studies/Author	Purpose of Study	Results of the Study
1	Comparison Among Different Green Buildings Assessment Tools: Application to a Case Study/ Mattoni, B., Asdrubali, F., Baldinelli, G., Bianchi, F., Bisegna, F. (2019)	• point-based methodological approach • It is based on the identification of six common macro-areas that allow the homogeneous comparison of the three green building assessment tools.	• CASBEE considers more aspects and sustainability issues compared to Green Star and ITACA. • CASBEE results are high and comparable among the six new macro-areas: the building scores the best certification level while Green Star, had the lowest • The building achieved very different final scores with the three systems: the best was CASBEE while the worst was Green Star • it is difficult to achieve a common sustainability language due to different calculation Tools, different credits, and weights applied by each green rating systems.
2	Asian green building rating tools: A comparative study on scoring methods of quantitative evaluation systems /Zhang et al., (2019)	Scoring method of terminal indicators between two GBTS and the Evaluation Standard for GB	• identified eight types of scoring method of terminal indicators utilized in the two GBTs. • Ecological sustainable green buildings has four and Ecology, Energy Saving, Waste Reduction, and Health with the greatest importance given to Direct Scoring Method and Formula Scoring Method • GBTS are seen as a hierarchical structure composed of Indicator System and quantitative evaluation system • Formular scoring method is associated with flaws shortcomings such as its limited flexibility and dependence on database

Table 2-8: Summary of comparative study (cont.)

S/No.	Comparative studies/Author	Purpose of Study	• Results of the Study
	Comparative Analysis of GBRS for Improvement opportunities/ Luangcharoenrat and Intrachooto, (2019)	A comparative study of nine (9) green building evaluation standards from both developed and developing countries to find similarities and differences to make future improvement	Most building evaluation systems focuses mainly on environment and then economic while pay less attention on social side and most criteria gives higher emphasis to energy and environmental mitigation issues
4	A comparative analysis of site planning and design among green building rating tools, Huo et al., (2017)	To understand the measures that help improve GB's site planning and design (SPD).) in GB.). To record and relate the appropriate SPD-related items in the selected GBTs	• Building Environmental Assessment Method (BEAM) Plus allocates the highest importance in Site planning development (SPD) while Green Mark (GM) allocates the lowest. • Each GBRT emphasizes different aspects of SPD in green buildings, and BEAM Plus involves the most SPD related items
5	Review on green building rating tools worldwide: recommendations for Australia, Illankoon et al., (2019)	Compared green building rating tools in Australia and other countries or regions around the world.	• This research found that rating tools in Australia do not have (1) compulsory criteria and (2) guidelines and motivation. • lack of (1) mandatory criteria and (2) regulations and incentives
6	Comparison of Assessment Systems for Green Building and Green Civil Infrastructure Liu et. al., (2019)	Studied and summarized different parameters and appraisal issues, and made comparisons among some major GBRTs for GB	• B/d structure, energy consumption, healthy air and temperature, illumination of the indoor environment, rainwater, and underground reservoirs are found in green building assess. Green infrastructure assessments that are: durable, benefits, landscape, humanities, culture, and creativity assessments,

2.12.3 Comparison of methods

The prominent rating tools (BREEAM, LEED, GREEN STAR, CASBEE, and DGNB) were presented as summarized in Table 2.8 and appendix G. The names/titles of some of the criteria were different but, the application was the same. For example, LEED had indoor environmental quality while in BREEAM it was called health and well-being. Some tools had more criteria than others, BREEAM and Green star had 9 conditions while CASBEE had 4 categories broken down into individual criterion. CASBEE and DGNB had a different approach to assessment, where the various environmental and social-economic criteria were summed up in categories.

Each tool has a different number of credits, ranging from 9 to 73 points, and each award has a different score, which adds up to the final evaluation mark. Because the credit points were different in the tools it may be difficult to compare a building that has been rated with one tool with another. LEED, BREEAM, and Green Star had mandatory criteria to qualify for certification, while DGNB and CASBEE did not have any. Mandatory criteria may be good for comparison but if one was to look at the state of building in Zambia most low-cost housing development would not fulfill those mandatory requirements. All GBTs have third-party independent verification assessors who do the validation either throughout the evaluation process or at the end. CASBEE has a self-assessment program where building owners provide evaluation results that a third party examines and certifies. The client is responsible for the assessors' fees, and some instruments have multiple evaluators. LEED, for instance, offers green and energy raters. Having all these assessors may make the process of rating very expensive especially for developing countries like Zambia.

Table 2-9: Description of prominent rating tool

Prominent Rating tools	**Developer /Year**	**Country of origin and applied**	**Rating categories**	
LEED	United States Green Building Council (USGBC) in 1993.	United States, Canada, India, Brazil	1. Energy and atmosphere 2. Water efficiency 3. Sustainable sites	4. Materials and resources 5. IEQ 6. Innovation
BREEAM	Building Research Establishment (BRE) in 1990	United Kingdom	1. Energy use 2. Transport 3. Water 4. Ecology and Land use	6. Materials 7. Pollution 8. Health and well-being 9. Management.
CASBEE	The Japan Sustainable Building Consortium (JSBC), 2001	Japan	1. interior comfort 2.scenery consideration	3.environmental awareness 4.energy saving materials
GREEN STAR	Green Building Council of Australia (GBCAUS), 2003	Australia, South Africa, Kenya	1.Energy 2. Transport 3. Water 4. Ecology and use and Emissions	6. Materials, 7. IEQ 8. Management, 9. Innovation
DGNB	German Sustainable Building Council (DGNB), 2009	German	1.sustainable building 2. environmental 3. social-economic	5.technology 6.processes 7. site quality

Most GBTs lack an integrated assessment methodology since social and economic, cultural, and local participation criteria were excluded. An integrated system was recognized as the optimal framework in studies such as the following: Wang and Zhang, (2016); Alshamrani et al., (2014); Thompson and Roux, (2010); Collinge et al., (2015); Hikmat and Nsairat, (2009). Considering the environmental, social, and economic aspects of sustainability when evaluating buildings was acknowledged as critical to meeting the SDGs. Although other comparative studies have shown that the environmental dimension is the most important in all evaluation standards, the assessment improves the quality of GB and adds to the benefits of the users (Luangcharoenrat and Intrachooto, 2018; Berardi, 2013; Wang et al., 2018; Fithian and Sheets, 2017. Sharifi et al., 2013 and Fenner et al., 2008). Through the integration of various tools and methods, the green building tool that was developed included social and economic assessment and local adaptation and user participation.

The GBTs were subdivided into ecological, environmental, and social and economic categories. Each criterion is weighted to get the final grade, as shown in Table 2.9. LEED has nine ecological categories with 110 credit points and eight prerequisites. BREEAM has ten environmental categories and 55 credits points. DGNB had six categories and 61 credits, while CASBEE had five categories and 43 credits. Green Star had ten categories with 29 credit points, and DGNB had all criteria equally rated. DGNB had similar categories to LEED and BREEAM, but the interpretation for each of the categories was different. With regards to LEED, DGNB and CASBEE, there is an emphasis on the LCC on the materials used in the buildings, while in the other tools, the LCC is embedded in the criterion. In BREEAM, the social-economic parameters are mentioned, while in the rest of the tools this criterion is not explicit. All the rating tools except CASBEE had independent assessors who are employed by the building owners to carry out the evaluation. Although the assessment is done by independent assessors the influence of the client on getting a good rating cannot be overlooked. In CASBEE, there are two rating levels: building load and building efficiency. A government wing is engaged in the assessment of CASBEE criteria; thus, the assessment process is unique.

In each of the GBTs, the scores indicated the importance placed on the criterion. Unlike the other tools, the LEED rating system focused primarily on green building practices and offered only a few credits for site selection and design (LEED, 2019). In terms of their certification, the Green Star adopted a star rating from 1 to 6. LEED used a scale of platinum, gold, silver, and bronze to indicate a higher or lower rating and BREEAM adopted a scale from pass to excellent. CASBEE had levels scores from 1 to level 5. One of the challenges seen in the tools was the different points given for the same criteria, for example, in the LEED system, the point given for water efficiency was 12 percent, while in Green Star, it was 8 percent. The scales given to various criteria should reflect national or regional needs. Thus, flexibility is required in rating the criteria and priority should be given to those parameters that will obtain the greatest positive impact on the environment. The two guidelines, SBAT and SHG, were not included in the comparison of evaluation and certification processes of GBTs because they lacked detail on credit points. They were only included in the assessment of criteria and categories (Appendix H).

Table 2-10: Comparison of criteria in selected GBTs

	i. LEED	i. BREEAM	i. DGNB	i. CASBEE	i. Green Star
Methods	ii. 9 ecological categories iii. contain prerequisites. iv. 110 points in 55 credits and additionally, 8 prerequisites must be fulfilled. v. Third-party certification vi. green rater to verify the project. vii. a qualified energy rater to verify the energy components viii. preliminary and final reviews ix. Integrative method x. evaluate the xi. environmental performance of the whole building over its life cycle	ii. 50 credits iii. 10 environ. iv. Performance quantified by individual measures and associated criteria expressed as a single certified BREEAM rating, v. -BREEAM Assessor engaged vi. rewards environmental, sustainability vii. mitigate the life cycle impacts of new buildings	ii. 6 categories iii. 61 credits iv. based on quantitative measures v. life cycle assessment vi. Assessment of LCA and LCC vii. 3 stages of assessment - Integrated design viii. all categories are equally weighted. ix. indicators that are evaluated either qualitatively or quantitatively. x. Each criterion has a value of ten points xi. Presence of a xii. DGNB auditor	ii. 43 credits iii. 5 categories building environ. quality and performance iv. building life cycles. v. BEE value of the Comprehensive building assessment throughout the life cycle of the building vi. Built load. vii. Building Efficiency indicator viii. 3 assessment levels of the building specification	ii. 29 credits iii. 10 separate environmental impact categories iv. Promote integrated, whole-building design; v. A Green Star SA vi. the environmental weighting factor is then applied to each of the project's category scores to reach a single score. vii. weighting factors vary across rating tools

The comparison of the two guidelines SBAT and SHG is on the basis that they were developed in the two countries under review South Africa and Zambia. the criteria comparison is shown in Table 2.10. SBAT and SHG have 73 and 11 criteria, respectively. They were developed to support other GBTs and allow for a first-level assessment. These guidelines give strategies to achieve green building compliance. SBAT had the highest number of criteria for assessing buildings, but the number of categories were few and divided into environmental, economic, and social. SHG had few criteria, but within each criterion were sub-criteria.

Table 2-11 The comparison between SBAT and SHG

Methods	SBAT	SHG
	i. 73 criteria ii. performance of a building in relation to several economic, social, and environmental criteria. iii. impact of the building on the local economy, as economic issues iv. guide in terms of sustainability through. simple performance indicators v. A decision support tool	i. 11 criteria ii. responsive and integrated approaches to developing sustainable housing in Zambia. iii. used to improve understanding of sustainability. iv. used to monitor and evaluate the integration of sustainability in housing

2.12.4 Comparison of certification fees and number of rated buildings

Only LEED and BREEAM councils charge a registration fee (Table 2.12). However, LEED registration was $900 more expensive than BREEAM. Green Star has an extra cost for obtaining submission guidelines of $600. Pre-certificate is the cost of the pre-construction stage used by LEED, BREEAM, DGNB, and CASBEE. The cost of certification may be prohibitive for green low-cost housing thus contributing to the low utilization of rating tools in developing nations. Individual developers would lack the resources to undertake an assessment. Due to the low number of organizations undertaking low-cost housing development, few houses would be assessed. Therefore, the cost of assessment does matter in achieving green low-coat houses.

Table 2-12: Comparison of tools based on cost, use and certification

Name of Tool	Cost of certification	Registered projects	Region of use	Process of certification
LEED	-LEED registration =USD 2,900 -Pre-certification =8,500.00 USD -Certification =2500 sqm 6,500.00 USD	32,500 LEED building projects	-150 countries USA, Canada, India, China, United Arab Emirates and Brazil	-8 stages -Connect with green rater organization develop LEED scorecard and preliminary rating -Schedule site inspections for verification -Green rater review and submit to USGBC for certification
BREEAM	-Registration of asset =USD 1,000.00 -Initial certificate = USD 1,873.00 -Certificate =2,150.00 USD	569,928 BREEAM certified projects	83 countries mostly in Europe	-6 stages -Pre- assessment stage -Design stage assessment -Interim design certification -Construction stage assessment -Final post construction certification
Green star	-Submission guidelines USD 600.00 -0-10,000 sqm =USD 8, 500.00 -10,000 - 29,999m² = $9,400.00	2,539 certified	Projects in Australia, others are South Africa, Ghana, Rwanda, Namibia, and Kenya	-9 stages -Prepare Round 1 submission -Round 1 assessment -Clarification of assessment comments -Prepare Round 2 submission -Round 2 assessment
DGNB	-Up to 2500 sqm -Pre-certificate USD 7,367.00 -Certification USD 5,550.00 -Certificate complete project ->2 floors USD 8073.00 & USD -2,227.00 charge up to 10 criteria	500 certified	30 countries worldwide projects in Europe mainly, China, Vietnam	-5 stages -Registration of the building with the DGNB -Goal definition for building performance -Pre-certification as marketing tool -Assessment during planning and construction -Evaluation of planning and construction documentation
CASBEE	-Certification cost USD 3,570.00-4,500.00	330 certified	Mainly in Japan	-6 stages -CASBEE assessment results -BEE built environment efficient. /Life cycle calculation

Green Star certification from 0 to 10,000 sqm cost the most, at USD 8,500, followed by LEED ($6,500), DGNB up to 2,500 sqm was $5,500, CASBEE ranged from $3,500 to $4,000, and BREEAM ($2,150). BREEAM had the most projects certified with 569,928, followed by LEED with 60,000 certifications.

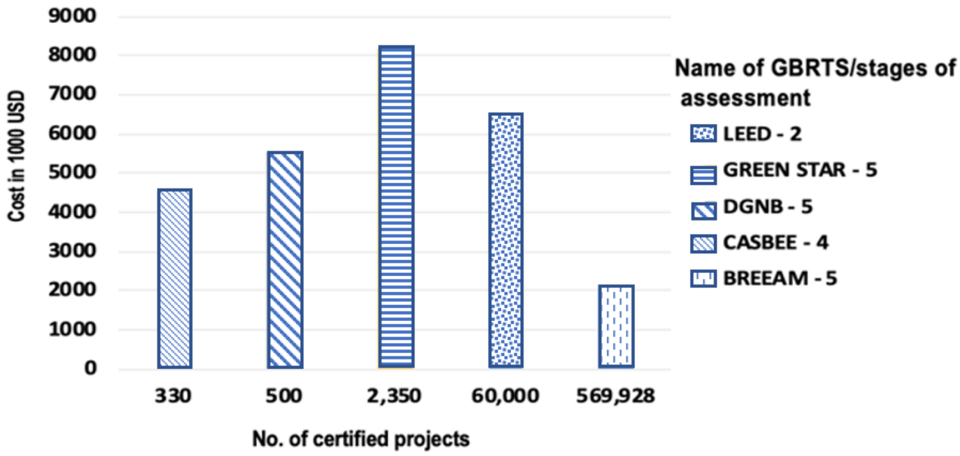


Figure 2-7: Comparison of GBTs cost of assessment and certification
Source: author

CASBEE had the lowest number of projects and the second-lowest certification cost, with 330 recognized projects. Most projects were certified using BREEAM and LEED. There was no correlation between the cost of certification and the number of certified projects for each of the GBTs except for BREEAM, which had the high number of certified projects and the lowest cost of certification.

Many of the tools had similar pre-certification phases, between two to five stages. There was no link between certification phases and the number of certified projects. A country-by-country comparison shows that LEED was used in 150 countries, followed by BREEAM in 83. DGNB had a low intake, with only 30 nations in use, while the least common was CASBEE used in Japan and a few Asian countries. BREEAM and DGNB are primarily used in Europe and portions of Asia, while LEED is widely used in most countries.

Most of the tools have a pre-assessment stage to determine whether projects are green enough to be certified. BREEAM assessors use a set criterion, technical documents, and accompanying assessment tools to analyze the entire building process. All GBs councils require that the assessment be conducted by an independent assessor hired by the customer. All assessors must be registered with the individual green building councils. Much of the documentation for LEED certification must be completed by a project team. After the information is acquired, an application is created that can be divided into a design and construction review with certification provided by a LEED qualified third-party assessor. The Green Star certification method is comparable to LEED certification in that information is acquired by a third party (Liu et. al., 2019).

Some conduct a single assessment, whereas others conduct multiple evaluation stages. These may include the registration to pre-assessment, initial guidance/design stage assessment, construction, and post-construction review/final certification. BREEAM has four to five stages of assessment, starting with a design and construction evaluation, which is further divided into a preliminary and final review. LEED comprises four stages of assessment. Round one evaluation and round two submissions by an impartial panel of sustainable development specialists are the only two points of assessment for Green Star. Other GBTS have one tool that covers all stages of building, whereas CASBEE offers four assessment tools for distinct construction stages.

The differences in the certification price makes it easy for those who consider price as a factor otherwise the disparity should not be too high. The comparison between the cost and the number of ratings done shows that there is no relation as Green Star that had the highest price, was the third most used tool. This shows that the selection of the tool does not necessarily depend on the price.

2.12.5 Comparison of key criteria in tools

All the tools have similar criteria, except SHG, DGNB and SBAT, which include education, participation, local economy, social, cultural, and technical quality. Energy, materials, indoor environmental quality, water management, ecological site, and transportation are the primary criteria among the GBTs (Illankoon et al., 2019; Luangcharoenrat and Intrachooto, 2019). The main criteria in the GBTs are summarized in Figure 2.8. Energy criterion was highly scored in all the tools especially in LEED. Indoor environment was the next highest score, followed by materials and water management.

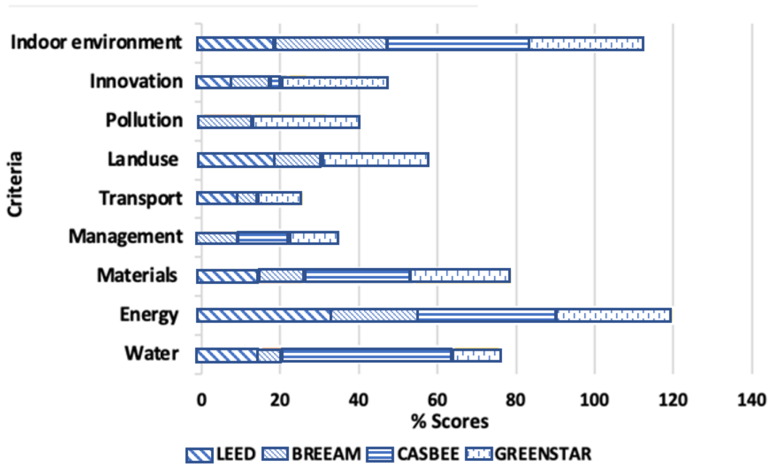


Figure:.2-8: Comparison of the main environmental assessment criteria

Source: author

Transport and innovation were the least scored. Energy reduction and monitoring receive the highest scores in LEED, BREEAM, CASBEE, and Green Star, with 20, 17, 35, and 32 percent, respectively as shown in Figures 2.9,2.10,2.11, 2.12, 2.13 and 2.14. The indoor environment is the second-highest criterion in LEED, accounting for 17 percent of the total score. For BREEAM, health and well-being and land use are highly rated. The indoor environment and material resources are rated highly In Green Star. Management, regional priority, innovation, process quality, and water management were the least rated of all the tools. Material resources and sustainable sites were CASBEE's second-highest criteria, each scoring 20 percent. From this comparison it shows that four main criteria are found in most of the tools being energy, water, materials, and internal environment. These criteria may have the biggest impact on the environment hence their commonality. However, the scores for each one of them differ and could depend on the effects each one of them has on individual countries where the tools were developed (Mattoni, et al.,2019).

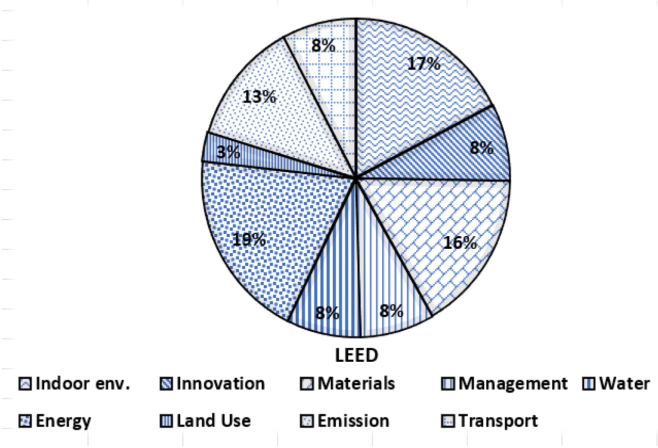


Figure: 2-10: LEED

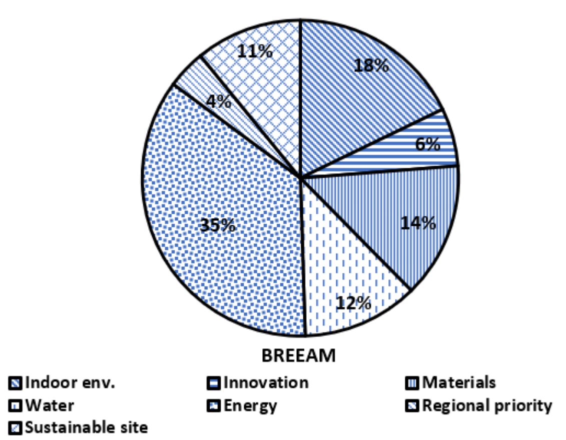


Figure 2-9: BREEAM

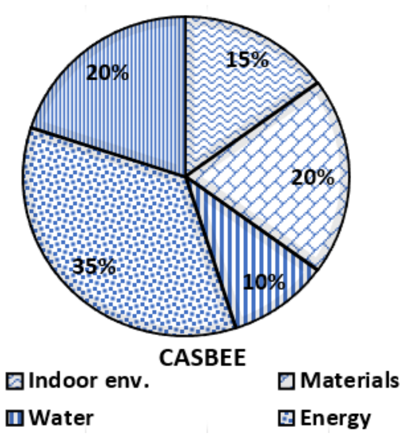


Figure: 2-11: CASBEE

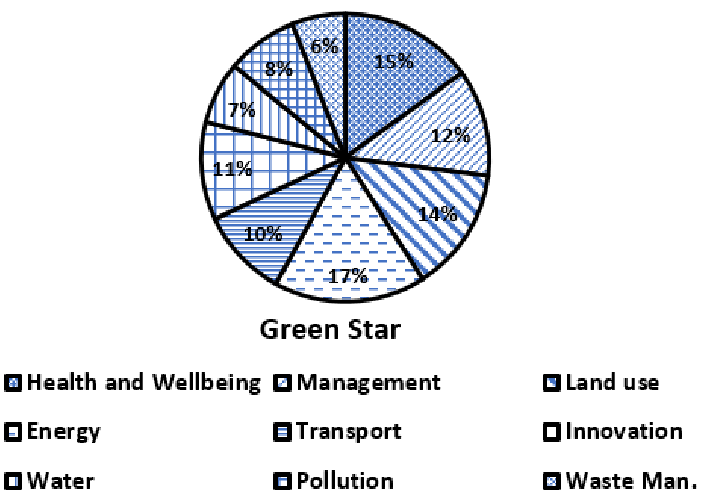


Figure: 2-12: GREENSTAR

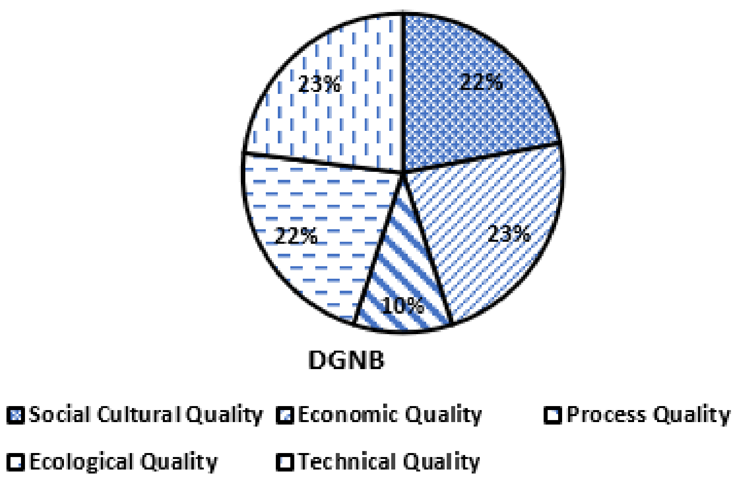


Figure: 2-13: DGNB

2.12.6 The criteria for SBAT and SHG

Since SBAT and SHG do not have credits, they were not included in the GBRT certification comparison. However, it was crucial to include them in the comparison study because they are an attempt to guide the development of GBTs tools in Zambia and South Africa. The guidelines provide a simple assessment and can be used as a reference for determining the environmental impact of buildings.

The energy component supports energy conservation and alternative energy use. Artificial and natural ventilation systems, heating and cooling systems, energy-efficient fittings and devices are all included in the guidelines.

2.12.7 Comparison of energy criteria

The energy efficiency criteria were compared in the tools. All of them strive to reduce energy consumption by utilizing energy-efficient technology that reduces carbon emissions into the atmosphere (Hafez, et al., 2023; Liu, 2021). Renewable energy was also used in most of them. However, DGNB does not expressly set energy as a separate criterion, instead, it is incorporated into other categories. The requirement for efficiency in the utilization of renewable energy such as solar and in building service systems is explained in CASBEE. As a result, it incorporates both natural and artificial energy-saving methods, as shown in Figure 2.15. Energy control in SBAT and SHG is achieved using solar energy, passive ventilation, environmental control, and cross ventilation.

In SHG there is also energy serving using biogas and biomass. BREEAM, Green Star and LEED energy efficiency is achieved by energy metering and energy-efficient equipment. There is also a concern for the reduction of greenhouse gases and enhanced refrigerant management. BREEAM has three criteria: energy-efficient transportation system; low carbon design; and energy-efficient cold storage that is not found in any other GBT. There is peak energy; and photovoltaic systems in Green Star and SHG, respectively and these were among the criteria found in some but not all GBTs.

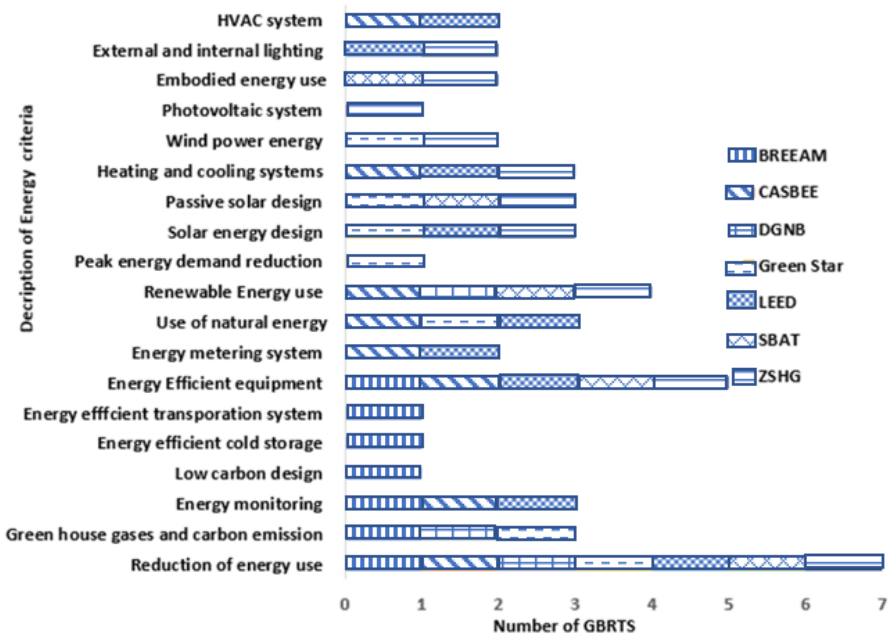


Figure: 2-14 Comparison of energy criterion in GBTs
Source: author

2.12.8 Comparison of other criteria

The water management criterion is to ensure that the commodity is used sustainably. It is controlled by reducing water use and leaks throughout the entire water delivery system (Al-Qawasmi. Et al., 2019; Nahiduzaman et al., 2018). Reducing potable water use (internal and exterior) over the building's lifecycle and minimis leakage losses, followed by recycling systems and rainwater harvesting (Amr, et al., 2015; Almeida, et al., 2021). Except for BREEAM, DGNB, and CASBEE, all tools show the soft and hard landscape that prevents surface runoff by directing water to storage stations or underground drains.

Indoor environmental quality is the ability to establish an inside environment that provides for optimal visual, thermal, and air quality (Akanmu et al., 2020). Most of them have thermal comfort and indoor air quality, while four of them have visual comfort, ventilation, and acoustics. Others consider both natural and artificial ventilation, while SBAT refers to it as ventilation by natural means. LEED deals with low-emitting material criteria, whereas BREEAM describes it as managing harmful emissions from construction products by specifying finishes and products that have been tested (BREEAM, 2018).

Sound insulation, low-emitting materials, and humidity management were only evaluated in CASBEE, LEED, and Green Star, which also included hazardous material control. Environmental tobacco smoke control is referenced in LEED and Green Star. However, it is not specified directly in others.

The use and reuse of materials with low embodied energy and life cycle cost, were common in all the tools followed by sustainable construction items, recycling waste storage, and minimal health risk materials. Only SBAT and CASBEE evaluate embodied energy in construction materials and the use of CFCs and halons. The durability and resilience of the materials in the building are mentioned in SBAT, LEED, BREEAM, and CASBEE.

The material specifications range from one region to the next. Where wood or timber is widely used, there are requirements for acquiring and using the materials as provisioned in LEED, DGNB, and CASBEE. SHG mentions the use of timber from sustainable sources and the use of local earth blocks. CASBEE and SHG bring out the aspect of reusability of components and materials. SBAT and SGH encompass details of using local and renewable materials with low embodied energy.

Each tool had its own unique set of criteria, including innovation, regional priority, education, local conditions, social-cultural, and community involvement. Management was the most common among these criteria. The second most popular criterion was regional priority, also known as local standards or conditions in some cases. DGNB, SBAT, and SHG all have economic requirements. In SBAT and SHG, the local economy was attributed to empowering the community through job creation, whereas in DGNB, it is about the long-term economic viability of building materials (life cycle costs). Innovation was defined as any idea that the design team might come up with that enhanced the buildings and contributed to their greenness outside of the standard categories of BREEAM, LEED, and Green Star (Pham et al., 2020). DGNB considered country-specific adaptations as well as regional considerations.

SHG has similar requirements to SBAT, such as local economy, health, education, and social cohesion. The criterion for education used in BREEAM was not the same as the one used in SBAT or SHG. BREEAM educates tenants and landlords about maintaining sustainability in buildings, while in SBAT, it was about the provision of educational facilities and internet within the building structure to enhance the benefits of occupying the building. Education in SHG was about improving education and skills levels in GB within the construction industry. Aspects of social cohesion and safety in SBAT and SHG looked at the participation and interaction of the users in the buildings, especially the disabled, and securing access in and outside the buildings (Gibberd, 2005; MLG, 2016).

The selection of the criteria that was used in the development of the tool under study was based on studies like: McArthur, (2014); Bahaudin et al., (2014); Abolore, (2012); and Nazirah, (2009), who supported the use of energy, water, materials use, pollution, and indoor environment quality as the most highly rated criteria.

2.12.9 Regional specificity of tools

There are specific criteria that are unique for each region and although there were similarities in the selection of the criteria from the various tools, other factors came into play. For example, energy was a highly rated criterion, but specific indicators like the use of HVAC, and artificial heating and cooling systems were not given priority due to the high cost of installation. There was also energy serving using biogas and biomass in SHG. In LEED, submeter water systems, such as Water Sense-certified fixtures and low-flow fixtures are shown. In SHG there is a reduced operational cost of water. In BREEAM it talks about low emitting products for indoor air quality while in CASBEE they talk about sound insulation and humidity control. Whereas in Green Star they mention hazardous materials. When it comes to material use SBAT uses embodied energy in construction materials and CASBEE the use of CFCs and halons. When it came to land use and ecology the regional specifics were public image and social conditions seen in DGNB. It's also only in DGNB that you see cultural criteria mentioned.

Even though material efficiency is important for sustainable buildings, the materials in the tools are different from what is appropriate for Zambia. For example, tools such as LEED and BREEAM regard wood as a renewable resource but in Zambia, it is not sustainable due to uncontrolled deforestation. Clay was included in the concept because it is a more sustainable building material for Zambia. The promotion of local expertise, building material supply, local component makers, outsourcing opportunities, and repairs and maintenance are the main thrust of SBAT and SHG. What was also regional specific about SBAT and SHG were education, participation, local economy, social, cultural, and technical quality.

2.12.10 Challenges of using green building rating tools

The challenge of using the current tools to develop low-cost green houses in Zambia is the relevance or the absence of some criteria to achieve green compliance. There is very little information on the life cycle cost of the materials available in Zambia; thus, depending wholly on life cycle analysis as a basis for assessment is a challenge (Zulu, 2019; Oke et al., 2018).

Most developed countries possess rating systems, however, most of them are based on the BREEAM or LEED standards. These systems have very little social and economic criteria suitable for Zambia, hence many countries like Japan and most Arabs states have come up with their own rating systems. GB is designed and constructed to reflect local conditions and the resources available. Therefore, rating tools developed in one country cannot be applied in another country without adjusting them. Liu et. al., (2019); Illankoon et al., (2019); and Zuo et al. (2017) stated that there are difficulties in applying these tools because they were developed for national desires and reflect the priorities of the conditions they have emerged.

2.12.11 Desk review of literature summary

Literature review determines the meaning and relationship among the various narratives that influence a study (Gheyle and Jacobs, 2017). It may involve the presence of words, phrases, and themes to quantify and analyze the presence, meanings, and relationships. This research used literature review to demonstrate the various narratives on GBTs. It demonstrated ideas for developing GBTs that are regionally specific. A summary is given in Table 2.13, where the various schools of thought are put together to demonstrate the theories and concepts behind the study methodology and design.

The challenge seen in the GBTs is the variance in the results when measuring the same buildings. The other school of thought is that the tools assume all regions to have the same parameters, which is not the case, and social-economic and cultural criteria were not common in most rating tools. Some authors mentioned that tools do not address the various green building expectations. It is very difficult to possess tools meeting all regional needs; thus, the encouragement is for territories to develop their own tools. The other challenge seen in the literature review was tools that do not address the issue of the cost of assessment, and yet this was identified as a big barrier to the utilization of GBTs

Table 2-13: Literature review of summary of reviewed documents

Author	Year	Title	Objectives	Methodology	Analysis of the study	Strength
Bungau, C., Bungau, T., Prada, I.F., Prada, M.F.,	2020	'Building Design and Construction, Green Buildings as a Necessity for Sustainable Environment Development: Dilemmas and Challenges.	It provides a comprehensive assessment of GBTs in the context of sustainable development, and principles of application while integrating green materials and circular economy into the general scientific framework	Literature review	- The GB solution, which is defined by sustainability and energy efficiency, is introduced, and described in the study paper as a cogent strategy for the sustainable design of the future. - Some of the solution may not apply in the context of developing countries. - scientific literature, is largely approached from a strictly engineering perspective and not sufficiently from an occupant/beneficiary-oriented perspective	It provides a comprehensive assessment to explore the progress and the current scientific framework of GBTs, including design, certification systems, circular economy, renewable energy sources, and green materials
Zulu. E., Zulu, S., Chabala, M., Musonda, I., Kavishe, N., Nicholas Chileshe,	2022	Challenges and advocated solutions for environmental protection legislation for building infrastructure projects in developing countries: Evidence from Zambia	- Environment protection legislation is often inadequate and poorly implemented in developing countries. - - The study argues that environment protection legislation is adequate but with inadequacies in its implementation.	exploratory qualitative approach	- Because the study was exploratory and quantitative with a very small sample, the conclusions cannot be statistically generalized. - Due to the small number of environmental practitioners in a developing nation like Zambia, the sample size was relatively small	- Due to the sample size the qualitative study was appropriate. - Had rich source of data - Highlighted Environment protection legislation is often inadequate and poorly implemented in developing countries. - Solutions include increasing the level of implementation of the legislation and championing environmental awareness.
Sharad R. Khese, Hedaoo M.H, Konnur B.A	2019	A Comparative Study of Rating Systems in Green Buildings	The paper presents the comparative review of four. prominent sustainable green building rating systems namely BREEAM, LEED, GREEN STAR and GRIHA.	Comparative analysis	These systems are based on different Parameters and rate the same buildings differently. Also, they are quite complex in nature and do not necessarily give a clear idea of the project effectiveness	- study considered all aspect of the rating systems under study to ascertain of best one(s). - The study provided a deep insight into sustainable. green building rating systems

Table 2-14: Literature review of summary of reviewed documents (Cont.)

Author	Year	Title	Objectives	Methodology	- Analysis of the study	- Strength
Zhong Y. and Wu P.	2015	Economic sustainability, environmental sustainability and constructability indicators related to concrete- and steel-projects,'	This study investigates the performance of reinforced concrete framed (RC-framed) and structural steel framed (SS-framed) buildings on economic sustainability, environmental sustainability, and constructability performance indicators in Singapore	Case study	- Does not give enough detail on the methodology and the specific reason for the selection of the projects. - Achieving economic sustainability, environmental sustainability and constructability performance has been the challenge that the construction industry needs to address.	- The demonstrates the connection between economic and environmental sustainability even in the choice of steel - It brings out the need to capture the LCA of materials to reduce its economic impact on the environment
MLGH	2016	The sustainability Housing Guidelines	To give guidelines for the development of parameters to use in attaining green buildings in the housing sector	Documentation review	- The guidelines elaborate the history of housing, the challenges and the green interventions required to achieve housing in a sustainable way - To improve the understanding and awareness of sustainable housing by key stakeholders - involved in the housing development sector. - To provide guidance on the design of sustainable housing. - To support sustainability performance monitoring and evaluation of housing.	- The guidelines are detailed enough to allow for strategies to be implemented in housing development and give specific intervention to achieve green housing. - It's the first documentation prepared in Zambia that clearly outlines what can be done to achieve sustainability in the housing sector
Aghimien, D.O., Aigbavboa, C., Oke, E.A., Musenga, C.	2018	Barriers to Sustainable Construction Practices in the Zambian Construction Industry	It is based on assessing the barriers to SC practices within the Zambian Construction Industry (ZCI)	A quantitative approach	The study type was not clear but described as qualitative.	The study has been able to ascertain the most significant barriers impeding the full implementation of SC practices in Zambia.

Table 2-15: Literature review of summary of reviewed documents (Cont.)

Author	Year	Title	Objectives	Methodology	Analysis of the study	- Strength
Basten, V., Berawi, M.A, Crévits, I., Latief, Y.	2019	Conceptual development of Cost-benefit analysis based on green building's regional, knowledge, and economic aspects	It proposes the development of a CBA method for evaluating building aspects to define the goals of green building indicators.	Literature review	Confirmed that efficiency achievement, financial evaluation, and national economic evaluation measured the feasibility of investment in green building development	- It developed a decision-making Tool to solve the problems of constraints of green building implementation. - Validated the framework through in-depth interviews with some green building experts in finalizing the CBA framework
Agbajor, D.F., and Mewomo, C.M.	2022	Green building research in South Africa: A scoping review and future roadmaps Energy and Built Environment'	To provide a scoping overview of the intellectual exploration on green building research in the South African context.	Literature review, systematic review	- The implementation of financing schemes, utilization of advanced digital technologies, and promotion of green and sustainable building curricula across the institutions as well as post-occupancy-related studies - GB research is not full-fledged within South African academic/research community. - all keywords within the GB domain were not explored. - The worth/value of most articles included in the eligibility criteria were not evaluated in this study.	- Used Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR)
Mohd Isa, N.K., Abdul Samad, Z. and Alias, A.	2014	Review on Sustainability Principles of Building: Formulation of a Theoretical Framework	This study aims to explore the sustainability principles of building by reviewing relevant literature and identifying the principles in the sustainability literature relevant to building projects.	Literature review	- A theoretical framework of sustainability principles of the building was then formulated to be the main outcome of the study - The framework consists of a list of 29 sustainability principles of building to be	- The formulation of a framework in the study where 29 sustainability principles were taken into account - The framework was developed by considering the environment, social, economic and design and innovation aspects

Table 2-16: Literature review of summary of reviewed documents (Cont.)

Author	**Year**	**Title**	**Objectives**	**Methodology**	**Analysis of the study**	- **Strength**
Sonay Aykan	2013	Green vs. Sustainable: analyzing and expanding LEED	The study investigates the possibility of including new socio-economic indicators in green building rating systems to promote innovative practices in the building	comparative analysis and questionnaires	Has depicted the intertwined relationship among the building industry, labour markets, financial and legal forces, and shows that development of socio-economic indicators for the building industry is not impossible, but is bounded to the methods of asset value calculations, regulations on labour markets, workflow structure of the building industry and the political structure behind the rating systems	- It has shown that green building certification is a significant step towards attaining sustainability in the building industry - created a system of continuous data collection and analysis regarding the conditions affected by the operations of the building industry
Banana R., Vahdati M. & Elmualim A.	2013	Demonstrating the importance of criteria and sub-criteria in building assessment methods	This paper aims to demonstrate the importance of criteria and sub-criteria in developing a new potential building assessment method for Saudi Arabia.	comparative analysis	This study has shown that the categories of assessment methods are interrelated to each other, and regional preferences are considered in the assessment criteria.	provide a solid foundation to develop an effective sustainable assessment method for buildings in Saudi Arabia
Windapo, A. O.,	2014	Examination of Green Building Factors in South Africa Construction Industry. Department of Construction Economics and Management	An empirical investigation into the factors of green building in South Africa	comprehensive literature review approach using a multi-case study	- too many study methods were used in the study - the research is limited by its small sample size and the location-specific nature of the multi-case study approach..	- The use of case studies - it provides factual evidence of the factors of green building and whether those factors have changed over time

Table 2-17: Literature review of summary of reviewed documents (Cont.)

Author	Year	Title	Objectives	Methodology	Analysis of the study	- Strength
Anshebo, A.M., Mengesha, W.J., and Sokidoc, L.D.	2022	Developing a Green Building Assessment Tool for Ethiopia		systematic review	The Analytic Hierarchy Process technique was applied for weighting and prioritizing after selecting these assessment categories and criteria.	- The paper provides a more systematic review on the sustainable considerations of green building than previous efforts in the literature. - It developed new green building assessment categories and criteria - the need to promoting sustainable building methods for a balance between economic, social, and environmental performance - It reviewed the most widely and commonly used practices using the AHP technique,
Assylbekov, D., Nadeem, A., Hossain, M.A., Akhanova, G. and Khalfan, M..	2021	Factors Influencing Green Building Development in Kazakhstan	the factors that hinder and the factors that can drive green building development in Kazakhstan.	literature review and online questionnaire survey,	- The results revealed a lack of skill/experience, a lack of government support, and the high cost of sustainable materials and products as the most crucial barriers - Water and energy efficiency, improved health of occupants, comfort, and satisfaction were identified as the most influential drivers - The results were generally nonsignificant, which might have been caused by the relatively low sample size for each category	- Comparing factors to barriers results reveals a higher level of confidence among respondents rating the drivers, having higher mean values - By expanding knowledge on factors affecting the implementation of green buildings, the study uncovered common trends in the responses of professionals, providing valuable information for field professionals

Table 2-18: Literature review of summary of reviewed documents (Cont.)

Author	**Year**	**Title**	**Objectives**	**Methodology**	- **Analysis of the study**	- **Strength**
Ayarkwa, J. Opoku, J.D., Antwi-Afari, P., Yi Man, R.	2022	Sustainable building processes, challenges, and strategies: The relative important index approach	Undertaking an extensive critical review of literature	empirical analysis	- The identification of sixteen challenges and sixteen mitigation strategies and conducted a cross-sectional survey among 200 Ghanaian construction industry professionals. - Inadequate training and education, unfamiliarity with green technologies, and higher initial costs of green construction practices and materials are the key challenges that hinder project delivery	- Guided approach on how to mitigate the challenges in adopting sustainable building practices through the adoption of the proposed strategies. - Used a quantitative analysis from 200 construction experts
Awadh, O. (2017) anal	2017	'Sustainability and green building rating systems: LEED, BREEAM, Green Star and estidama critical analysis	Presents an objective analysis between two internationally applied GBRSs; LEED and BREEAM, and two particularly developed for the gulf region; Estidama and GSAS.	Field survey and participatory technics	- BREEAM, G. Star and Estidama systems give the highest weighting to the Energy category while LEED prioritizes the Indoor En. Quality - Enhanced energy performance credit is given the highest weighting in the four systems. LEED is the most lenient in energy performance credits while Estidama is lenient for renewable energy	-Aspects such as climate change adaptability and the importance of sustainable communities and cities trend identified. -To help designers and construction stakeholders in defining the development sustainability targets and objectives, without compromising on the local context and regional agenda.
Bond S. and Perrette G.	2011	The key drivers and barriers to the sustainable development of commercial property in New Zealand	To identify the key drivers and barriers to the sustainable development of commercial property in New Zealand (NZ) by surveying a cross-section of these market participants.	Quantitative study	- An appreciation of the uniqueness of the different barriers and drivers and how they are regional specific should have been emphasized - It could have benefited with qualitative information	The investigation of the barriers and drivers included both the professionals and the developers which means the information from the study could benefit the community

Table 2-19: Literature review of summary of reviewed documents (Cont.)

Author	**Year**	**Title**	**Objectives**	**Methodology**	**Analysis of the study**	- **Strength**
Ntshwane K., Essah E., and T. Dixon T	2014	Investigating the level of awareness of building assessment tools in the construction industry of Botswana	The research aims to investigate the knowledge and level of awareness of environmental building assessment tools among industry practitioners in Botswana.	Quantitative research	The methodology on the barriers was not clearly explained, and why the barriers were selected	- The response rate for the study was high at 65% thus could be inferred to the general population. - Both qualitative and quantitave data was used thus giving strength to the results
Alsanad, S., (2015)	2015	Awareness, drivers, actions, and barriers toto sustainable construction in Kuwait	The study showed that 63 percent of the respondents were aware of the GBTs	Mixed method	- Other studies have shown that awareness of GBTs does not translate to high utilization of the tools - It failed to bring out the implementation of the current legislation	- The implementation of green construction methods is low and no regulations - lack of awareness was found to be the main barrier to the use of
Häkkinen & Belloni, (2011)	2011	Barriers and factors for sustainable building. Building Research &Information,	where the fear of higher investment costs for sustainable buildings compared with traditional buildings are addressed as barriers		Many studies have shown that the perceived high cost of GB is really a lack of understanding that all those costs do make the running of buildings less costly in the long run	Clearly stipulates the various barriers to undertake green building analysis

2.13 Findings from the Literature Review

The major findings from the literature review were that:

i. there is low knowledge and utilization of rating tools in developing countries particularly in Africa, thus the need to look at reasons behind the low use and to investigate the factors associated with that;

ii. there is a need to have assessment tools that are regionally specific or that take into consideration adaptation to climate and locality, hence it is important to adapt criteria with similar regional priority;

iii. LEED has been stated to be the most widely used tool, and other tools are developed using its framework. Consideration of LEED as one of the tools from which criteria could be adapted was implemented;

iv. GBTs should be developed with integration, transparency, and accessibility in consideration, hence consideration for combining various methods and making the tools accessible are factors to consider;

v. comparative research demonstrated why particular criteria were considered and showed the strengths and weaknesses of selected tools;

vi. the literature showed the structure, performance, category weighting and documentation requirements for certification. These variables could be used for the development of the tool;

vii. literature reviewed 15 factors affecting the utilization of GBTs, and the most common were financial and political constraints, the lack of building codes, regulations, awareness, and market. These factors were included in the variables for association of factors in the regression model.

2.14 Summary

Chapter two examined a range of available literature on the use and development of GBTs, describing the GB Movement, the characteristics, the knowledge, and utilization of tools in the world, in Africa and Zambia. It pointed out possible factors associated with utilization of GBTs. Environmental, social, economic, criteria are important for achieving green low-cost. The main factors associated with use of GBTs were a favourable political atmosphere, government involvement in green building development, and perceived environmental benefits. According to the literature, there is no universal GBTs, and each region selects one that is appropriate for them.

The comparative analysis of five GBTs, SBAT, and SHG was detailed in the chapter. The comparison was based on certification costs, country utilization, quantity of certifications, and the kind of assessment criteria employed. The certification cost was similar for most tools except Green Star which was the highest and BREEAM was the lowest. There was no correlation between certification costs and the number of GBTs users. The findings revealed that most GBTs favoured environmental assessment over social-economic or cultural assessment. The key criteria found in all the GBTs were energy, indoor environmental quality, material and resources and water management.

The methods for performing the research are discussed in Chapter Three. It shows the possible direction of the theoretical framework and a description of the problems associated with the development of green low-cost houses. The problem analysis helped to identify the causes, the problem, and the effects of the variables in attaining green low-cost houses. The research design, the study population, the sample, and the sampling processes used were all explained. In addition, the chapter discussed the study's research tools, reliability, data processing procedures, and ethical aspects.

CHAPTER 3 METHODOLOGY

3.1 Introduction

Chapter Two presented a literature review of the study. It outlined the development, use and challenges of the existing GBTs. The argument was that the existing GBTs do not have all the necessary criteria to meet the planning and assessment requirements for GBs in Zambia. The literature review presented studies that compared various rating tools and highlighted possible variables that could be used in the study. The goal of evaluating buildings, the criteria employed, and the progress made in green construction were meant to be applied in the development of a new tool.

Chapter Three presents the study's research techniques. A pragmatic paradigm, which allows for researchers to have two worldviews positivism and constructivism study approach. The pragmatic paradigm permitted the use of both objective as well as subjective epistemology. An explanatory sequential mixed method design was adopted, where data was collected through a questionnaire survey and interviews with selected professionals in the Zambian building industry. A stratified sampling was undertaken from a study population of building industry experts from two of Zambia's largest provinces. The mixed-method design allowed for the collection of qualitative and quantitative data to strengthen the study findings.

The selection of the studied variables was developed from literature review. The problem tree diagram in Figure 3.1 identifies the challenges and strategies that the Zambian building industry is facing to achieve GBTs. The three main forms of assessment were environmental, social, and economic. A breakdown of each form shows the connection of the independent variables to the dependent variable (development of sustainable, low-cost houses).

The dependent variable is to achieve green or sustainable low-cost houses for Zambia through the development of local GB tool. The independent variables were the environmental, economic, and social factors and experiences of the respondents (cost of assessment, environmental adaptability, demographic characteristics, and comprehensiveness of tools). The policy and laws governing GB development, the finance, available materials, and the education on GB also can affect sustainable housing development.

3.2 Theoretical Framework

Concepts, along with their definitions, and the current theory or theories that are employed for a specific study make up a theoretical framework. The theoretical framework must show an understanding of ideas and concepts that are pertinent to the research subject and that connect it to other, more general domains of knowledge. (Adom, et al., 2019).

The concept of housing can be viewed from several perspectives, including housing as a physical structure and an entity with both social and economic values, housing as it relates to the neighborhood and its immediate environment, and housing as a locational access point for the delivery of infrastructure services (Chiamaka and Aduwo, 2019). The theoretical framework looks at housing as a process that integrates sustainable housing development with project processes, with sustainability goals, stakeholders, and the institutional environment.

As a result, to properly define sustainable housing development, it is necessary to look at housing as a good, a service, and a process. The interaction of housing development elements like strategic location, good planning and design that preserves aesthetics, adherence to construction and operation guidelines, and the application of the sustainability measurement indicators like adaptability, affordability, marketability, and community participation; socioeconomic factors, political and cultural resources result into viable housing development.

The theoretical framework in the study was adopted from Nair, et al., (2005). The first part of the theoretical framework is to identify the sustainable development parameters which include four key factors—economic, social cultural, technological, and environmental sustainability. All these factors are important for the welfare of people and societies and are interrelated. The framework demonstrates how several sustainability factors interact during the housing development process. Additionally, it outlines the policies and procedures that must be taken to achieve the objective of sustainable, affordable homes as seen in Figure 3.1.

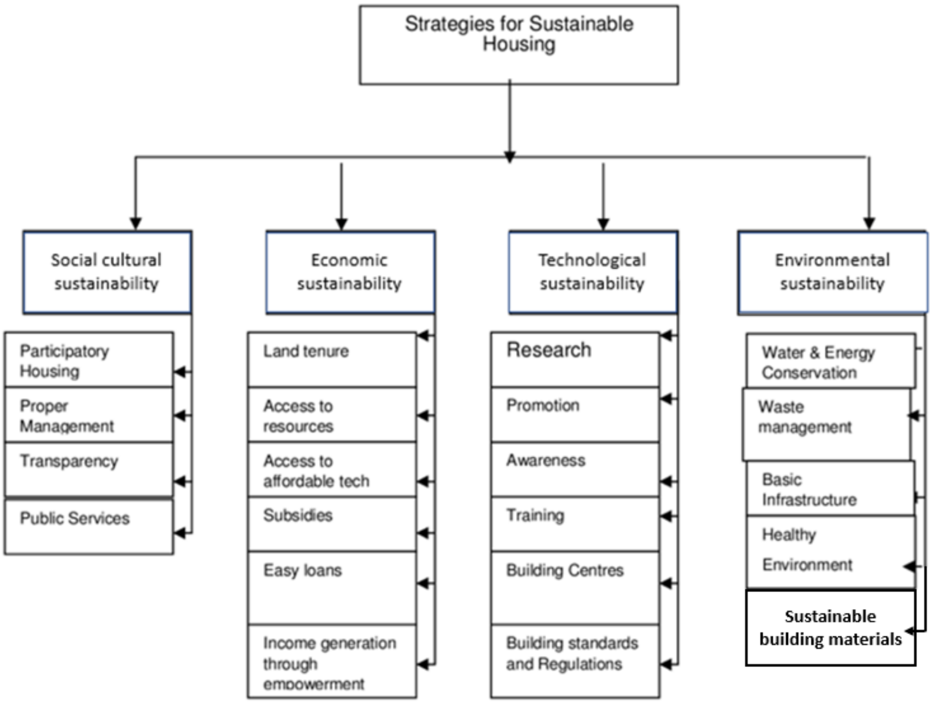


Figure 3-1: The theoretical framework for sustainable housing development *After Nair, et al., (2005)*

3.3 The problem Analysis of Sustainable Housing

According to Veselý, A., (2022) a problem tree structure provides an overview of all the known causes and effect to an identified problem. This provides the framework in which a project is to take place. Contextual awareness makes life's complexity more apparent, which is crucial for planning a successful change project (Erridah. and Lotfi, 2021). The problem tree structure enabled the division of the issue into smaller, more manageable problems. This makes it possible to prioritize factors more clearly and helps keep goals focused. The problem and its frequently connected and perhaps conflicting causes are better understood. It highlights the key points and arguments and can be used to determine the various solutions to attaining green low-cost houses.

Sustainable housing challenges in Zambia can be looked at in a multifaced way. Firstly, there are historical issues that have led to the existence of poor housing. These historical challenges were both due to the colonial make up of Zambia, where good housing was specifically built for the colonial masters and no or inadequate formal structures were built for the natives. The influx of people migrating to the cities after independence increased the demand for housing. Then there were institutional challenges of the government withdrawing from active housing development and leaving it in the hands of the private sector. The economic decline of the 1980s made housing development unfordable, due to high construction and material cost and unaffordable loan facilities. These factors in the Zambian economy exasperated some of the root causes of unsustainable buildings identified in the problem tree analysis. The problem tree diagram in Figure 3.2 shows what has been identified as the root and underlying causes and effects of unsustainable housing development.

Some of the root causes outlined include the absence of green building materials, green building rating tools, laws and standards and green building training strategies and criteria. Most of the materials being used in housing development are unsustainable. The absence of green building byelaws means people go on constructing without following laws and guidelines. Poor knowledge about green buildings will entail people building with no regard for sustainability. When there are no regulations, people have very little knowledge about the requirement to achieve green low-cost houses. Because of the poor implementation of green building strategies in housing there will be poor housing that lacks important green criteria such as efficient energy use. All these causes will result in poor unsustainable housing for communities. The developed houses will lack durability and resilience and will be vulnerable to the effect of climate change. The running cost will also be unfordable as there will be poor service delivery in these houses.

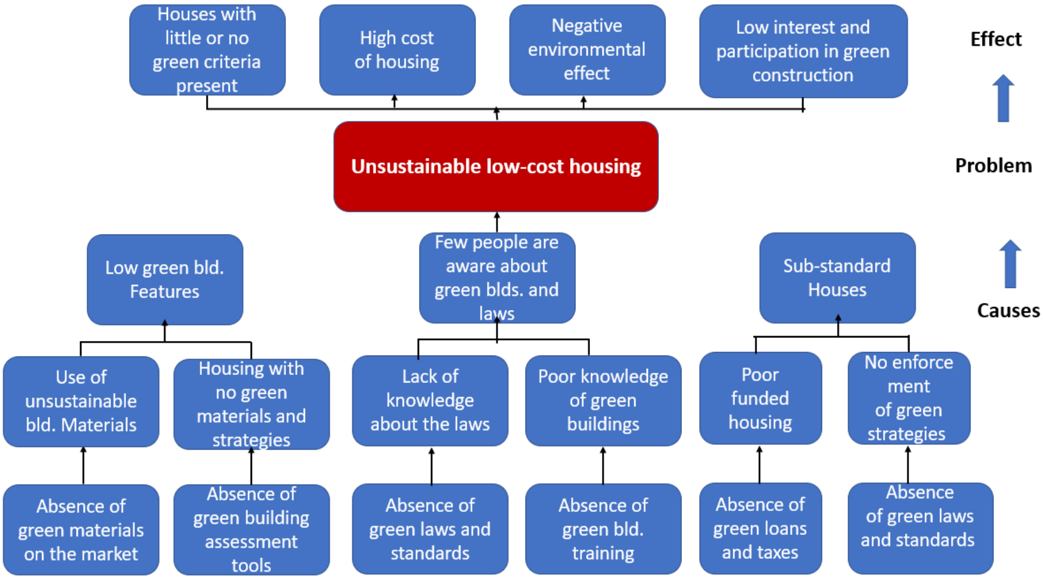


Figure 3-2: Problem tree diagram
Source: author

These indicators not only require the three pillars of sustainability but also community participation, access to resources and land tenure. Technological sustainability looks at research, training and awareness of housing and environmental sustainability looks at resources and infrastructure.

3.4 The Research Paradigm

The Research Paradigm refers to the culture or worldview of beliefs, values, and methods within which a study takes place (Kivunja et al., 2017; Žukauskas, et al., 2017). A basic tool or framework that organizes a researcher's point of view and reasoning is known as a research paradigm (Babbie et al., 2010; Hussain et al., 2013). There are two positions in an inquiry: the positivist position and the interpretive position. The former looks at studies as objective, while the latter looks at research as subjective. Creswell (2015) describes an inquiry as being objective when it claims to describe a true and correct reality, which is independent of those involved in the research process, while subjective studies generally refer to the biased experiences of respondents and to the fact that the investigator’s perspective is embedded within the study process, rather than seen as fully detached from it. Research is based on a philosophical worldview, and this influences the type of design undertaken. The paradigms include; the Positivist, Social Constructivist, Radical, Phenomenological, Advocacy and Participatory and Pragmatic Worldview. The study did not elaborate on all the paradigms but selected only those that applied to the research.

Every study has a philosophical worldview, and with it comes strategies for collecting and interpreting this information. The type of research design that an investigator chooses depends on the inquiry strategy related to the worldview and the research questions at hand.

3.4.1 Pragmatism paradigm

Pragmatism is a paradigm that seeks to reconcile the naturalistic methods and free-wheeling orientation of newer approaches with the scientific method and structuralist orientation of earlier approaches (Creswell 2013; Creswell and Plano Clark 2011). Pragmatism as a research paradigm finds its philosophical foundation in the historical contributions of the philosophy of pragmatism (Maxcy 2003) and, as such, embraces plurality of methods. As a research paradigm, pragmatism is based on the proposition that researchers should use the philosophical and/or methodological approach that works best for the research problem that is being investigated (Tashakkori and Teddlie 1998). However, pragmatic researchers disprove the purists' view that qualitative and quantitative approaches are mutually exclusive and instead engage in discussions that highlight parallels between the two and encourage triangulation (Tashakkori and Teddlie 1998). It is often associated with mixed-methods or multiple-methods (Biesta 2010; Creswell and Plano Clark 2011; Morgan 2014a; Teddlie and Tashakkori 2009), where the focus is on the consequences of research and on the research questions rather than on the methods. It may employ both formal or informal rhetoric (Creswell and Plano Clark 2011).

Due to the nature of the research questions, pragmatism was appropriate as it allowed for the use of methods and tools that could best answer the research questions and solve the research problem. The research questions required the investigation of variables and the causal effect on the outcome and the use of the experience of the respondents in coming up with solutions to the challenge of developing Green Low-cost houses. The research methods used in the study required consideration of a paradigm that would allow for multiple uses of methods and testing of variables for correlation. Therefore, the study adopted the pragmatic approach as the research questions required investigation of the experiences of the experts and developing themes that would be used in the qualitative study. Some aspects of the research problem could be viewed with the constructivist paradigm, which assumed that professionals have subjective meaning due to their background and experience of what they consider appropriate for GB assessment. The pragmatic viewpoint was relevant because the research sought to find practical ways for adopting green building in low-cost housing development.

3.5 Research Design

The study design's goal was to lay out the stages and approaches (methods) that would be employed to respond to the research questions. The researcher recognized a knowledge gap that might be filled by literature evaluation, and the research design guided in answering the research questions. Crewel (2015) defines research design as detailed plans and procedures to collect data, analyze, and interpret. It is a technique, according to Leedy (2010), in which a systematic and fact-based search for an answer to a question or a solution to a problem is conducted. Under quantitative, qualitative, and mixed-method approaches, a variety of research methods were investigated.

3.5.1 The quantitative method

Quantitative research, also known as positivist research, looks at experiments, empirical observations, or measurements; it aims at verifying theories and questions (Borgstede, and Scholz, 2021; Albers, 2017). The theories are tested by examining the relationship between variables. It focuses on the investigation of the variables and on proving their relationships, and empirical data is analyzed numerically and statistically (Ahmad et al., 2019; Ahmad, 2019). This form of design is objective since it aims to predict or explain relationships between variables and make generalizations that help advance theory. Quantitative research methods include descriptive, cross-section, and employ inquiry strategies, such as experimental, questionnaires, surveys, observations, secondary data, and mathematical Tools (Creswell, 2015).

3.5.2 Descriptive research

The quantitative design in this study started with descriptive research, which aimed at describing the phenomena and correlations between the study's many variables. According to Borrego et al., (2009); McCombes (2022), descriptive research only describes the data of the phenomenon but does not explain it and may describe the relationship between variables but cannot address them. The descriptive study examined GBTs usage with its associated factors.

3.5.3 Cross-sectional studies

A cross-sectional study was undertaken using the stratified sampling method, where a selected population of professionals in the building industry were randomly selected from their individual strata. It involved looking at data from a population at one specific point in time (Thomas, 2022; Creswell, 2015). The purpose of the study was to establish the knowledge and utilization levels of GBTs and identify the preferred criteria and factors in using tools. Cross-sectional studies are appropriate when finding out the prevalence of a phenomenon, situation, problem, attitude, or issue by taking a cross-section of the population (Engward, 2012).

3.5.4 Correlational studies

The correlational researcher studies one or more group qualities. It analyses the relationship between variables using techniques such as cross-tabulation and correlations (Bhandari, 2022; and Marlinyn & Goes, 2011). A single number describes the degree of relationship between two variables in correlation. This type of method was used in the study, where the dependent variable, utilization of GBTs was correlated with other independent variables, such as the cost of certification or the comprehensiveness of use of rating tools.

3.5.5 Explanatory studies

This is also known as analytical study. According to Creswell (2015), the basic goal of explanatory research is to find any causal relationships between the elements or variables that are relevant to the study subject (George, and Merkus 2021). Williams (2007) defines this as an investigation into how the independent variables are influenced by the dependent variables, involving cause-and-effect relationships between the variables. Experiments are the primary data source to test the causal relationship between variables. The method is limited because it does not explain why there is a causal effect on the dependent variables and whether the results can be applied to make changes to the problem. This type of research was used as the study's objective was only to justify the relationships between variables but not to explain the causal effect of the variables.

3.5.6 Classification

Under classification, objects or variables are grouped based on similar characteristics or traits (Goundar, 2012). It might be the first step in organizing various variables regarding their relationship grouping. This is particularly useful when dealing with several variables. The shortcoming of this type of design is that results obtained from this kind of analysis do not allow for strong findings to be made concerning the cause and effect between variables.

The classification was used as a first step in aligning different social-economic and environmental variables that were important for comparison. It was used as the first step in comparative analysis.

3.6 Qualitative Method

Qualitative research, also known as constructivism or interpretive research, is defined by Creswell (2015) as a method for analyzing and comprehending the meaning of individuals or groups assigned to a social or human situation. It looks at the participants' settings and derives data from them. Qualitative is known to be flexible, and the data is analyzed based on the participants' narratives (Aspers and Corte, 2019; Borgstede and Scholz, 2021). The data gathering is unrestricted, and it progresses from specific to broad themes studies to comprehend the data's significance. Not only pre-determined data is sought, but emerging ones as well. Questions relayed in this method are more in-depth, as it assumes that the answers lie in the respondents themselves. The qualitative design method was adopted because the participants' experiences, challenges, and perceptions were important to establish the relationship between variables and the factors to GBTs use. Examples of qualitative design are case study, ethnography study, phenomenological studies, grounded theory study, and content analyses. The main data collection tools were in-depth interviews and surveys.

3.7 Mixed Method Design

Mixed method design incorporates approaches from both qualitative and quantitative research. In solving the research topic, the two design methodologies complement one other (Timans, et al., 2019; Schoonenboom, and Johnson 2017). The use of mixed methods study is highly reliant on the research topic; if the research question is mainly qualitative, qualitative research will be used more than quantitative research, and vice versa. To answer the study questions, the research paradigm integrated both positivist and constructivism methods. A mixed-method approach was used because the investigation incorporated both theories. There are three types of mixed-method designs: sequential, concurrent, and transformative. An explanatory mixed method was used in the study.

3.7.1 Explanatory sequential mixed method

The explanatory design is a mixed methods design with two phases. The overarching goal of this strategy is to use qualitative data to explain or build on preliminary quantitative findings (Creswell, et al., 2015). For example, if a researcher wants qualitative data to explain significant (or nonsignificant) results, this method can be used (Morse, 1991). When a researcher intends to use quantitative participant characteristics to guide purposeful sampling for a qualitative phase, this approach can be used (Morgan, 1998; Tashakkori & Teddlie, 1998). This study adopted the explanatory method because further information was desired from the study population on the challenges and strategies required to achieve a GBs that can meet the sustainable requirement of the population. The study objectives could only be met if the information was both quantitative and qualitative.

3.8 Data Collection Tools

3.8.1 Questionnaires

A questionnaire is a research instrument consisting of a series of questions to gather information from respondents and is usually used in surveys (Abawi, 2017). There are many types of questionnaires and some open-ended, while others are closed-ended questions. According to Kaliba (2015) the advantages of open-ended questions are as follows:

i. issues that may not have been asked can be explored, thereby allowing the researcher to gain more information;
ii. information is given spontaneously, and it is more likely to be true than answers which are limited to choose; and
iii. the disadvantages of open-ended questions are that time-consuming to administer, requiring responses that are not numeric. This may involve analyzing all the questions and only summarizing the relevant information.

Closed-ended or structured questions offer a list of options from which respondents must choose what is most suitable. The options must be exhaustive and stiff (Achola and Bless, 1988).

Advantages of closed-ended questions include:

i. Answers could be recorded quickly; and
ii. Analysis of answers is very easy.

Disadvantages include:

i. Respondents may choose options that they might otherwise not have thought of, especially if the options are not exhaustive;
ii. Information may be missed because of inadequate response options and
iii. The respondents may lose interest and suffer from boredom and fatigue.

Questionnaires can also be self-administered surveys, in which the researcher posts the questions, and the respondents answer them. Self-administered surveys are less expensive, allowing for anonymity, which may lead to more honest responses, requiring no research assistants, and eliminating bias because all respondents are asked the same questions (Belisario, et al., 2015; Bhandari, 2020). The negatives include the inability to utilize them with illiterates and therefore having a low response rate.

One method of data collection used in the study was questionnaires. For the survey, there were closed-ended questions, and for the interviews, there were open-ended questionnaires. Closed-ended questions were employed to control and derive consistency in the data analysis, and they were a speedy technique for gathering information. Open-ended surveys enabled more detailed data collection on participant experiences with GBTs and the associated factors.

3.8.2 Surveys

Surveys are used to answer the who, what, where, and how questions and are related to the deductive approach (Saunders et al., 2009; Abawi, 2017). Surveys are useful in exploratory and descriptive research as they allow for the collection of large data in a sizable population in an economical way. The study employed surveys to administer questionnaires to the study population, and the responses were standardized so that they could be compared. This allowed for quantitative analysis using descriptive and inferential statistics.

3.8.3 Secondary data

Secondary data is gleaned from previous studies via literature review, and the researcher is only a secondary user of the information (Serra, et al., 2018). It is low-cost because it minimizes the expense of gathering raw data. The problem with secondary data is that it may contain sensitive elements to which the researcher does not have full access and information that is missing. Secondary data include paper-based sources such as books, journals, periodicals, abstracts, indexes, directories, research reports, conference papers, market reports, annual reports, internal records of organizations, newspapers, and magazines, and electronic sources, such as e-books, social networks, websites, and e-mail (Mwiya, 2015). The comparative analysis study used secondary data to collect information.

3.9 The Research Journeys

Figure 3.3. shows the research path taken in this study. The journey indicates that a pragmatic philosophy was adopted. The shaded boxes show which paradigm, application, process, methods, data type, data collection and analysis were used in this study.

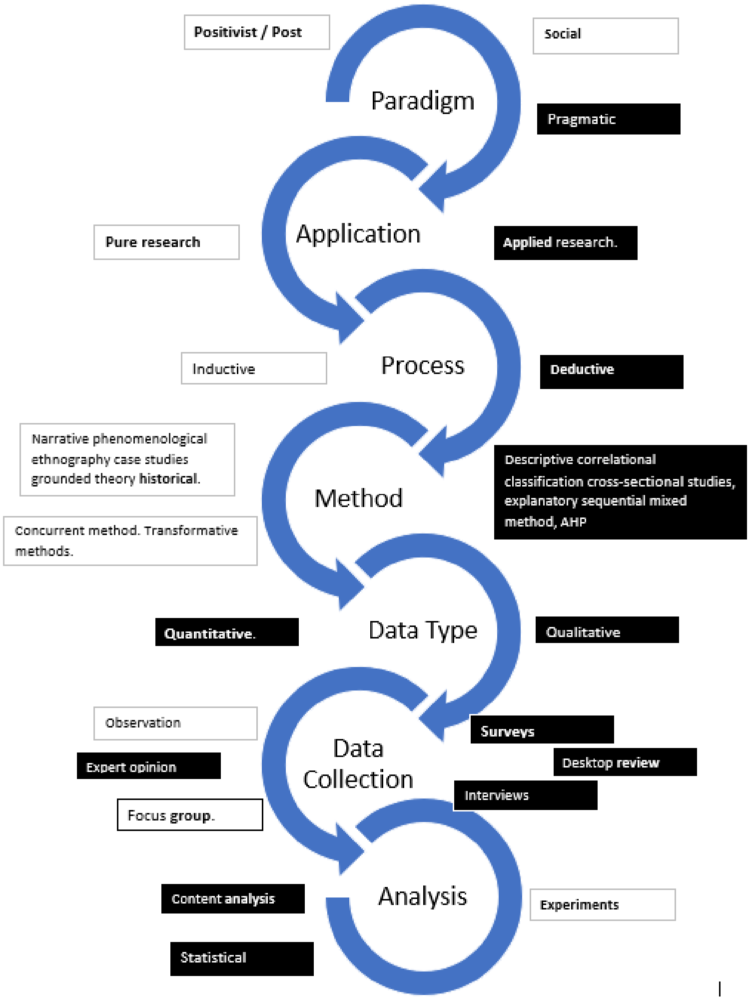


Figure 3-3: The research path diagram
(After Mackenzie and Knipe, 2006)

Since empirical evidence and experience of the respondents was required a mixed-method approach was used to incorporate two schools of thought and used applied research rather than pure research. Through a mixed-method design, real-world issues are provided with solutions that necessitate policy direction, laws, and guidelines to create a framework. Roll-Hasen (2009) stated that the purpose of distinctions between basic research and applied research is not to separate and isolate these scientific activities, but to grasp the differences to understand and further the interactions (Bentley et al., 2015; Sileyew, 2019). The selected methods were descriptive, cross-sectional, and correlational, which allowed for relations to be established amongst the variables. The data was quantitative as well as qualitative, indicating a mixed-method approach. Surveys, interviews, expert opinion, and literature were used to gather data.

To answer the objectives of the study, three studies were undertaken, namely:

iii. Comparative study;
iv. Analytical cross-sectional study; and
v. Tool design.

Friedrich and Trois (2011) adopted a comparative analysis to highlight critical gaps in Africa's present estimation of greenhouse gas emissions from garbage. Other authors who used a comparative analysis framework included Haapio and Viitaniemi (2008); Retzlaff (2008), and Zhao (2014). The purpose of a comparison study was to answer to the third objective of finding the criteria and strategies for assessing low-cost housing. The GBTs were compared in terms of evaluation costs, certification phases, and the types of criteria employed.

To achieve the first and second objective of the research, a cross-sectional study was undertaken, in which selected professionals in the Zambian building industry were surveyed and interviewed. The cross-sectional study was undertaken because it allowed for the collection of larger amounts of data in the shortest time possible, and it enables as much data to be collected as possible. It allowed for the comparison of several variables at the same time. Such a study enabled the use of both qualitative and qualitative tools.

Criteria selection by AHP was necessary because priority had to be given for criteria that would have the greatest impact in achieving green low-cost houses. The AHP was the best mathematical tool that would allow for a non-biased priority ranking of criteria. It allowed for the selection of both qualitative and quantitative data which was key in the study objectives.

The third stage of the study was developing an integrated assessment tool. Tool development was important as it demonstrated the possibility of having a measure for green low-cost housing. Combination of numerous criteria and procedures to aid in the planning and evaluation of low-cost houses was possible with the tool. The tool method allowed for environmental, social, economic /cultural, criteria assessment. It was a computer simulated tool based on a mathematical model with deterministic and static characteristics. An integrated tool design was chosen as the best method of developing the tool.

3.10 Study Design

An explanatory sequential mixed method design was adopted, starting with a quantitative questionnaire survey method with a 115 respondent, followed by a qualitative investigation employing interviews. The results of the interviews were used to explain the findings in the survey. To achieve the study objectives of investigating the knowledge and utilization of GBTs, and criteria preference, both quantitative and qualitative data were collected and analyzed. Adopting the explanatory sequential mixed approach requires the design and implementation of the quantitative strands, as shown in Figure 3.4. Analysis of data using descriptive and inferential statistics facilitated the selection of the respondents for the second phase. The second phase was to develop strategies based on the quantitative findings. This included using survey findings to develop a qualitative data collection protocol. The application and interpretation of qualitative data used the theme development approach. Comparing and contrasting the findings of the two studies was the last stage.

Sample size calculations were done separately because the two data components used different assumptions for calculating sample size. Respondents for the qualitative inquiry were drawn from the questionnaire survey sample population to allow for a homogenous flow of information.

Upon completion of the cross-sectional study, data was analyzed through Analytical Hierarchy Process (AHP), a mathematical decision-making technique that effectively deals with complex decision-making. AHP allowed for consideration of both qualitative and quantitative aspects of decisions. It has been used in the past by experts in sustainable construction who determined weights for assessment parameters.

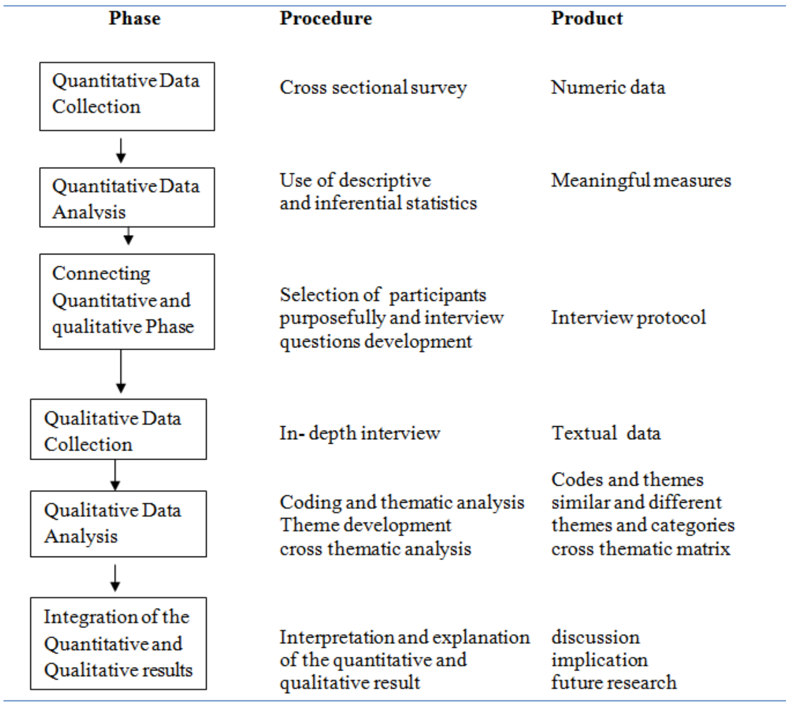


Figure 3-4: Explanatory Sequential Design

(After Creswell, 2011)

The AHP judgment is supposed to reflect the specific characteristics of the local environment (Markelj et al. 2014). Pairwise comparison was used to choose the technique and assessment criteria for the study. The experts are introduced at the start of the process, and they use the AHP pairwise comparative tool to pick the criteria. In the study Transparency Choice (TC) tool was used to make pairwise selection of the criteria.

3.10.1 Data types

Qualitative and quantitative data were used in the study from both primary and secondary sources. Primary data came from questionnaire surveys and interviews, (Appendix B and D) while secondary data came from literature review. Twenty (20) purposively selected respondents who held key positions in their organizations were interviewed using semi-structured questionnaires as an interview guide. Kvale (2008, p. 480) regarded interviews as *"an interchange of views between two or more people on a topic of mutual interest, sees the centrality of human interaction for knowledge production, and emphasizes the social suitability of research data."* The interview guide directed the discussion but allowed for further questions when the need arose

(Appendix F). There were both structured and unstructured questions in the style of interview.

Years of experience, number of projects completed, and number of GBTs used were all continuous variables. Sex, type of projects undertaken, organization one belonged too, and expertise variables were among the categorical data. Proportions were utilized to characterize most of the variables because they were categorical. The significance level was set at $p < 0.05$ and the confidence interval was set at 95 percent. Results were presented using tables and charts. Linkages between the dependent variable (utilization of tools) and several independent variables like knowledge, experience, project type, and relevance of GBRT were analyzed. A logistic regression analysis was run to determine the multiple effects of the predictor variables. All the variables that had a significant level of $p < 0.05$ in the binomial logistic regression were included in the multinominal logistic tool.

3.10.2 Secondary data

A review of literature was used to gather secondary data for the investigation. This method is cost-effective since it decreases the expense of gathering raw data and allows for analyzing trends in a study (The challenge related to secondary data was that most websites were not easily accessible due to several reasons including cost. Books, journals, periodicals, abstracts, research reports, conference papers, market studies, annual reports, internal records of organizations, newspapers, and magazines were utilized to complement the data gaps in the study.

3.10.3 Quantitative component

Quantitative data was used because of its ability to quantify generalizable variables and measure components in terms of quantity, intensity, or frequency with the intention of describing, explaining, and drawing conclusions from data obtained (Albers, 2017). In this study, quantitative design also allowed for the application of hypotheses and the establishment of correlations among the selected variables.

Data from the questionnaire survey, comparison study, and AHP were used in the quantitative component. The information was gathered to help determine knowledge and use of tools, factors associated with tool use, and method and criteria identification. Cross tabulation and regression were used to analyze the data.

3.10.4 Study population selection

The study was conducted in Lusaka, the capital of Zambia and the Copperbelt provinces, the industrial hub of Zambia. The two provinces were selected because they had the highest population of professionals (architects, quantity surveyors, valuers, engineers, and developers). The population was drawn from the list of members from institutions such as Zambia Institute of Architects or the Engineering Institute of Zambia. It included a quantitative component that investigated the relationships between tool usage and cost, comprehensiveness, knowledge, and environmental adaptability to the tools. The purpose of this type of research was to anticipate or explain correlations between variables and produce generalizations that would add to the theory of GBTs in Zambia. Qualitative data was collected to understand how professionals interpreted what they considered sustainable buildings in the context of Zambia. According to Creswell, the interviews allow the meaning that people or groups attach to a social or human situation to emerge (Creswell, 2015). The technique allowed data to be examined based on the interviewee's experiences. It was open-ended and built from specific to general themes to interpret the data.

3.10.5 Sampling and data collecting procedures

In a study, a researcher must choose respondents who give them the right information and the respondents must be representative of the whole population. Sampling is a process of selecting representatives from a population of objects or individuals (Sileyew, 2019). As stated by Welman and Kruger (2001), the population is the study object which may be individuals, groups, organizations, humans, products and events or the conditions to which they are exposed. Sampling becomes necessary when it is not possible to get information from an entire population when there are budget and time constraints. For example, many researchers, Babbie et al. (2010), argue that using sampling makes possible a higher overall accuracy than a census. The smaller number of cases for which you need to collect data means that more time can be spent designing and piloting the means of collecting these data. Collecting data from fewer cases also means that you can collect more detailed information (Saunders et al., 2012).

Stratified sampling was used in the study. It is a method of sampling that involves the division of a population into smaller subgroups known as strata. In stratified sampling, or stratification, the strata are formed based on members' shared attributes or characteristics, such as income or educational attainment. Only experts in the building industry and developers from the two provinces were purposefully selected. The first strata were the selection of some professional bodies (the architects, engineers, planners, quantity surveyors, valuation surveyors, developers, and contractors only in National Council of Construction (NCC) grade 1 category). Therefore, in each group a sample was taken based on the population size as well as how associated that group is in using GBTs. The architects were more because research indicated that they were the main users of GBTs. In the sample population's number of contractors and engineers was reduced in comparison to the overall population because these hardly use the tools as seen in studies such windapo 2016; Wu et al., 2019, Anshebo et al., 2022. Each professional organization was sampled separately, with different sample sizes to make up 271 participants as in the formula in equation 3-1. Every individual in the population had an equal chance and likelihood of being selected in the sample. A random number generator software was used to eliminate bias where a sequential number was assigned to each person (1, 2, 3…n). The software gave random numbers to the population, and a randomized command selected the sample population.

The sample size was worked out using the Daniel (1999) formula for a small population as follows:

i. Margin of Error (Confidence Interval) = +/- 5%.
ii. Confidence Level (90%) Z Score = 1.645
iii. Standard of Deviation = 0.5

The formula:

$$Z^{2}\, Std\,(1 - Std) / (Margin\ of\ error)^{2} \qquad \text{Equation 3-1}$$

Therefore:

$(1.645)^2$ x (1-0.5) / $(.05)^2$

= 271

A sample size of 271 was determined, there was a response of 115. This represents a 42% response rate. To make up for the low response rate a key informant interview was conducted. 10 key informants were interviewed. From the sample size of 271 the sample population was sampled from the individual strata accordingly: architects 37% (100), quantity surveyors 9% (25), engineers 19% (50), Contractors 9% (25), Valuation surveyors 9% (25), planners 9% (25) and developers 8% (21). The proportion was similar to studies like (Alsand et al., 2015 and Oguntona et al., 2019)

3.10.6 Qualitative component sampling and data collecting procedures

The sample of the key informant for the qualitative study was taken from the respondents in the quantitative study to have a homogenous flow of information. The quantitative study's questionnaire revealed that architects had greater knowledge about green buildings than the rest of the study population, hence only male and female architects were included in the sample population for the qualitative study. The condition for the selection of the respondents was that only architects were to be selected and should have scored above 80 percent in the knowledge questionnaire. The third requirement was that only people in senior positions, such as senior architects, partners, or directors, be chosen. Senior members were chosen since they were the only ones who could decide which rating tools to utilize in their organizations.

Having selected the key informant for the study, all the twenty (20) who were identified were invited to participate in the interview. However only ten (10) responded and were interviewed. The interview took place between May and June 2018, semi-structured interviews were performed to answer the study's third aim, which was to investigate the environmental, social, and economic factors associated with the use GBTs and the criteria for assessment. The qualitative research investigated the problems that experts in building projects faced while trying to use GBTs. An interview guide with open-ended questions was used to conduct the interviews (Appendix F). Key informant interviews were recorded on digital audio recorders with their permission. In addition, field notes were taken during interviews by the researchers.

Thematic analysis was used to analyze data in this study. This method involved identifying, analyzing, and reporting patterns within data. This was done by presenting data in a narrative form of words developed around emerging themes that were collected through the survey and interview. Each piece of data with a distinct code for reference purposes was identified. Kothari (2004) describes coding as a process of assigning symbols to responses so that they are placed into a limited number of categories. This enables the researcher to break down data into manageable themes, patterns, trends, and relationships to understand the various elements. Thus, the advantage of thematic analysis is that it helps in data collected being reduced and simplified, while at the same time producing rich, detailed, and complex description of recurring information for the purpose of interpretation (Nowell et al., 2017)

Several themes were developed from which the interview guide derived the questions. Data was collected on the participant's experience in using the tools, whether they found them easy to use, whether the tools covered all aspects of the assessment and if they were environmentally adaptable for the Zambian building industry. The study explored the challenges of acquiring existing or developing local tools. Also, the SHG of 2016 was reviewed to understand how relevant it was and how much could be applied in GB compliance.

3.11 Variables Selection

Variable selection is the method of choosing the correct parameters from a comprehensive list of variables while excluding any that are irrelevant to the study. The goal of such selection is to choose a group of variables that will offer the model with the best fit (Ratner et, al., 2013). The variables that were selected were those identified in literature review and were in line with the research objectives. Table 3.1 shows the variables that were considered and tested for association and ranking. Demographic, experience, and preference variables were included in the analysis. The data obtained were either continuous or categorical (yes or no) answers. The questionnaire was administered using face to face interviews (Appendix D).

Table 3-1: Measurement of Variables

Type of variables	Definition	Attributes	Scale of measurement
Dependent variable	Utilization of rating tools	Yes/No	Categorical
Independent Variable			
Demographics	**Sex**	Male/Female	Categorical
Experience	Years of experience 0-4 5-9 10-14 15-19 >20	Nominal	Continuous
	profession Architects Quantity surveyors Engineers Contractors Developers	Nominal	Continuous
	Residential Projects Non- residential Both residential and non-residential	1=residential 2=nonresidential 3= both Types	Continuous
Knowledge concerning GBTs	Availability of tools	Yes/ No	Categorical
	Cost of rating tool	Yes/No	Categorical
	Relevance of tools	Yes/No	Categorical
	Comprehensiveness of tools	Yes/No	Categorical
	Knowledge of tools	Yes/No	Categorical

3.11.1 Inclusion and exclusion criteria

The inclusion and exclusion criteria must be set before you start the review. Participants of the study must be assessed to see if they meet certain criteria to be included or excluded in the study. The key characteristics of the target population that the researchers will use to address their research question are referred to as inclusion criteria. Common inclusion criteria include demographic, clinical, and geographic features. Exclusion criteria, in contrast, are defined as characteristics of potential study respondents who match the inclusion requirements but exhibit extra traits that may hinder the study's effectiveness or raise the likelihood of a negative outcome (Patino et al., (2018); Amundsen et al., (2018))

In the quantitative study the inclusion criteria were solely professionals and members of professional institutes in the building sector. These included planners, developers, contractors, quantity surveyors, engineers, and architects. Only directors from National Council of Construction (NCC) grade 1 construction companies were included in the contractor population. The professions from Lusaka and Copperbelt were included, contractors with grade 1, and those who belonged to professional bodies were included. In the qualitative study only those who took part in the quantitative study and who showed high knowledge (above 80 percent) were selected for the interview and as evaluators. These professions also needed to be heads of firms, such as directors or partners. The exclusion criteria were that those who had not participated in the quantitative study and those with little knowledge on GBTs could not take part in the study.

3.12 Questionnaire Design

The questionnaire had 23 questions divided into three sections as attached in appendix D. Demographic data, type of tools utilized and factors affecting the use of tools were part of the first section of the questionnaire. Knowledge of GB and their strategies was captured in the second section, the third was the factors influencing the use of tools and the last section contained ranking criteria. The questionnaire's categorical and Likert scale-based questions are included. The questionnaire's bulk of questions were purposefully brief and closed-ended. The selection of criteria had a scale from one to five, with five being the most important and one being not important. The reliability of the questionnaire was tested using the Cronbach test of reliability.

3.12.1 The Cronbach's alpha coefficient test of Reliability

To test the reliability of the questionnaire, especially for the Likert scale questions a Cronbach's alpha coefficient test was undertaken. It measures the reliability of a series of questions. It is frequently used in statistics to show that scales and tests created or used for research projects are appropriate for the task at hand (Taber, 2018). A scale is a collection of questions, and each of those questions is an item. Hence, Cronbach's alpha is a measurement of a scale's internal consistency and, consequently, of the degree of its dependability. The usual range for Cronbach's alpha reliability coefficient is 0 to 1. The internal consistency of the scale's items is inversely correlated with how near Cronbach's alpha coefficient is to 1.0.(Tavakol and Dennick, 2011).

The score from each scale item is added to the total score for each observation to produce Cronbach's alpha, which is then contrasted with the variation for all individual item scores. The best way to understand Cronbach's alpha is as a function of the total number of questions or items in a measure, the average covariance between item pairs, and the overall variance of the whole measured score (Goforth, 2015;).

A pilot study was undertaken to check the reliability of the questions using the Likert scale of 1 to 5. The results of the pilot study were worked out using the Cronbach formula in excel as shown in the equation 3-2 below.

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum_{i=1}^{k}\sigma_y^2}{\sigma_x^2}\right)$$ Equation 3-2

k the number of items in the measure

σ_y^2 variance associated with each.

- variance associated with the total scores.

$$\alpha = \left(\frac{5}{5-1}\right)\left(\frac{9.865 - 5.123}{9.865}\right)$$

= 0.6

The results showed that it was 0.6, and if possible, the Cronbach's alpha should not be below 0.6. Levels greater than 0.7 are regarded as acceptable. From the results the final questionnaire was adjusted so that reliability could be increased. Therefore, some of the questions were changed to increase the reliability. After adjustment, Cronbach's alpha test result was 0.7, an acceptable result.

3.12.2 Data quality control

A pilot study was undertaken to pretest the questionnaire before the fieldwork. It took the format of an online survey, where questionnaires were purposively sent to architects, engineers, quantity surveyors, planners, and developers outside the two provinces where the study was going to take place. A total of 30 people answered the questionnaire, and the results were used to improve the data collection tools. Several challenges were noted that needed to be corrected. One of the challenges was that some of the terminology in the questionnaire had to be explained by the investigators. A revision of the wording helped in collecting data when the actual survey was undertaken. To make questionnaire easier to follow, the questions that needed an explanation were changed to ranked questions.

3.12.3 Verification of questionnaires

The principal investigator and two research assistants collected the data. At the end of each field day, questionnaires were checked for completeness and given serial numbers. All questionnaires with less than ten percent (10) of the questions answered were rejected. After completing the data collection, a codebook was created, and all questions were coded. Questionnaire data was then entered into an excel worksheet. Data was cleaned to correct entry errors and then exported into SPSS statistical software for analysis.

3.13 The Likert Scales

The scale of measurement for the categorical variables was ranked on the Likert scale. Likert (1932) developed the principle of measuring attitudes by asking people to respond to a series of statements about a topic in terms of the extent to which they agree with them and so tapping into the cognitive and affective components of attitudes (McLeod, 2014). The Likert scale is a five (or nine) point scale shown in Table 3.2, which is used to allow the individual to express how much they agree or disagree with a particular statement.

Table 3-2: Importance in Likert scale

Likert scale for Importance
5.Very important
4. Important
3.Moderately important
2. Slightly important
1. Not important

(Iowa State University Extension, 2010)

Using the pairwise comparison, a scale from one to five is created to rate the relative preference of two items. One is not preferred (not important), five is extremely preferred (very important), and two is moderately preferred. A Likert scale assumes that the strength/intensity of an attitude is linear, that is, on a continuum from strongly agree to strongly disagree and assumes that attitudes can be measured. The scale measures, frequency, quality, importance, and likelihood statements. The responses would have a numerical value which would be used to measure the attitude under investigation. The advantage of the Likert Scales is that it allows the respondent to give an opinion, and this information is obtained with relative ease.

3.13.1 Analyzing Likert response items

Likert data will have a measurement scale assigned to Likert-type items. Likert-type items fall into the ordinal measurement scale, and these include a mode or median for central tendency, frequencies for variability and chi-square measure of association. While Likert-type items are measured by ordinal measurement, the Likert scale is analyzed at the interval measurement scale. Likert scale items are created by calculating a composite score (sum or mean) from four or more Likert-type items; therefore, the composite score for Likert scales should be analyzed at the interval measurement scale.

Descriptive statistics recommended for interval scale items include the mean for central tendency and standard deviations for variability shown in Table 3.3. Additional data analysis procedures appropriate for interval scale items would include the Pearson's r, t-test, ANOVA, and regression procedures (Bhandari, (2020). The limitations of Likert scale are that the validity is subject to attitude measurement and can be compromised due to social desirability.

Table 3-3: Data analysis procedure for Likert type and scale data

	Likert Type Data	Likert Scale Data
Central Tendency	Median or mode	Mean. Relative importance
Variability	Frequencies	Standard deviation
Associations	Kendall tau B or C	Pearson's r
Other Statistics	Chi-square	ANOVA, t-test, regression

Source: Boone and Boone (2012)

3.13.2 Data analysis using relative importance index

The data provided by the respondents in answering the factors associated with tool use in the questionnaire was analyzed using the Relative Importance Index (RII), as adopted from the study on the factors associated with sustainable construction in the Ghanaian construction industry by Djokoto et.al, (2014). The five (5) point Likert scale was used for ranking and the Index is computed in the formula in equation 3-3 as follows:

$$RII = 5n5 + 4n4 + 3n3 + 2n2 + 1n \,/\, 5(5n + 4n + 3n + 2n + 1n) \qquad \text{Equation 3-3}$$

Where: n1 is the number of respondents who answered "unimportant" or "very low"

n2 is the number of respondents who answered "slightly important" or "low"

n3 is the number of respondents who answered "moderately important" or "medium"

n4 is the number of respondents who answered "important" or "high"

n5 is the number of respondents who answered "very important" or "very high"

3.14 Methodology of Analytical Hierarchy Process

In answering the fourth study objective, the identification of the preferred criteria for assessing green low-cost housing, AHP was selected as the preferred scientific decision-making method. AHP generates a weight for each evaluation criterion according to the decision maker's pairwise comparisons of the criteria (Saaty,1980). The higher the weight, the more important the corresponding criterion. To utilize the AHP, the criteria weights are all combined to create one global score for each option and a resultant ranking. The global score combines the weighted sum of the scores and their consequential criteria. According to Elshafei et al., (2022) and Ramanathan (2001) AHP, as a compensatory method, assumes complete aggregation among criteria and develops a linear additive tool.

Information from the experts is utilized to estimate the relative magnitudes of factors through pair-wise matrix (Elshafei et al., 2022; Aliyev, 2022). Questionnaires are used to compare the relative importance between the two items. The pairwise matrix is created by using the scale of relative importance (Ishak, et al., 2019). The selection of an item is based on several criteria that will enable the best choice to be made on that item. In the case of this study, it was a selection of the best method and criteria to use in the assessment based on various criteria found in all the five GBTs that were considered. By adopting AHP, the use of multi-criteria decision is the basis for selecting the assessment criteria.

3.14.1 Process of selecting criteria using analytical hierarchy process

The process of selecting criteria using AHP tool starts with structuring a decision problem. AHP tool was tasked with determining the best approach for running a low-income housing assessment tool and determining the criteria for evaluation. In structuring the decision problem, it was decomposed into individual parts, including the objective, criteria, and alternatives. The method and parameter criteria organization were arranged into a logical hierarchy using AHP. It decomposed the relationship's complexity and helped identify the magnitude of each criterion for accurate comparison. The steps in coming up with a decision were outlined as follows:

i. develop a Model for the tool.
ii. derive weights for criteria.
iii. consistency check if weights are assigned correctly; and
iv. derive overall priorities and final decision.

3.14.2 Developing a model in analytical hierarchy process

According to Kasperczyk et. al., (2004); Ishak, et al., (2019) in developing a tool, there should be a goal on how the criteria would be selected or achieved. The goal was to come up with a method of assessing the impact of low-cost housing on the environment and selecting 20 criteria to be used for assessment.

3.14.3 Deriving weights for criteria

A decision is made on the relative importance of each criterion then a specific choice for each decision is made based on the value of the alternative criterion. The decision is ranked according to the priority given for each criterion and shows the preference for each of the various alternatives. A judgment is made on the relative importance of each criterion based on the influence that each of the criteria contributes to achieving the goal.

3.15 Validity, Reliability, and Generalizability

Muijs (2011); Parveen and Showkat, (2017), stated three key concepts in quantitative methods that have to do with measurement: validity; reliability; and generalizability. According to Winter (2000) and Leung (2015), validity is established if the research accurately measures the things that it was designed to assess or whether the research results were appropriate. The methodology, data gathering methods, and analysis all contributed to the study's validity, reliability, and generalizability.

3.15.1 Validity

There was objectivity and subjectivity as a pragmatic paradigm as the researcher's opinion were for some of the research questions not supposed to influence the findings and there was subjectivity for other research questions that would involve the experience of the key informant. The instruments used to collect data were both subjective as well as objective, being quantitative and qualitative in nature. To address the validity of the quantitative results, the usage of RII, correlation, and regression analysis were used. The different data gathering tools, such as the questionnaire survey and interviews, were suitable for the study's objectives.

3.15.2 Reliability

Drost (2011, pp. 105-124) defines reliability as*, "the amount to which measurements are reproducible when diverse people evaluate separate occasions, under different settings, supposedly with distinctive equipment that gauge the construct or skill."* If results are to be reliable, they must be consistent and repeatable (Leung, 2015). The instruments used in the study were comparable to other studies like those employed by Abu Bakar and Cheen (2013), CASSUD, and Gibberd's SBAT development. The mixed-method design would help to demonstrate reliability as the results from the various studies would complement each other.

3.15.3 Generalizability

The term "generalizability" relates to how far the research findings may be applied (Leung, (2015). It refers to how the study's findings may be extended to wider samples or populations (Ryan and Bernard, 2000; Parveen and Showkat, 2017). The sample group consisted of various individuals from the building industry and not only architects. Fisher et al., (1989); Zulu et al., 2020; Sutherland, (1991); Golove et al., (1996); Varone et al., (2000); Ofori, (2006); and Alsanad, (2015); Ntshwane et al., (2014); and Aghimien et al., (2018) all used sample sizes, aims, and research methodologies that were comparable to those used in this study. Since the studies above were conducted in different locations and produced similar results, it may be assumed that the sample population can be generalized to the general population.

3.16 Validation

Validation is assessing the degree to which an instrument accurately measures what it is supposed to measure. Tool validation is usually defined to mean "*substantiation that a computerized Tool within its domain of applicability possesses a satisfactory range of accuracy consistent with its intended application."* (Sargent, 2010). A tool should be validated to show that the results produced from the tool can be compared with real-time results. A tool cannot be tested for its validity in all its domains as stated by Sargent (2010, p. 170) that, *"It is often too costly and time-consuming to determine that a Tool is valid over the complete domain of its intended applicability. Instead, tests and evaluations are conducted until sufficient confidence is obtained that a Tool can be considered valid for its intended application."* The validation process of the tool was through expert opinion. The experts were involved in the development of the programme, and software. The professionals tested the operation of the tool and validated it.

3.17 Ethical Considerations

The research proposal was approved by the Natural Science and Research Committee (NASRECNASREC), reference number HSSRECHSSREC IRB NO. 0006465013-08-15 (Appendix A). The three ethical principles of researching human respondents were observed thus: respect for autonomy, beneficence, and justice. The research background was given to the respondents, and they were told of their right to choose to participate or not participate in the research. The intent of the results was also explained to them. It was clarified to them that the research carried no risks. This did not involve administering or handling any substance and no procedures that would entail physical examination. It was clearly explained in the information sheet (appendix B) that there would be no material benefits to the participants. Once the respondents agreed to take part in the study, they were made to sign the consent sheet (appendix C). Anonymity was observed by identifying the filled-in questionnaires and making use of serial numbers.

Before starting the interviews, respondents were assured that no part of the data being collected would be disclosed outside the research team and that the given information was for academic purposes and research publication. Verbal permission to record interviews was obtained before proceeding to record. For those respondents who refused to be recorded, notes were taken during the interviews. Key informant interviews were all conducted in the privacy of the interviewee's offices. Data generated from key informant was only shared with persons who were directly involved in the investigation. No names, organizations or personal identifiers were recorded on the questionnaires.

3.18 Study Limitations

Limitations were encountered in the study, and these were mainly due to the field of study that was new to many of the respondents. Many terminologies were new to the respondents and so the researchers had to explain some of the words used in the questionnaire. The following were some of the limitations:

i. Due to a lack of clear understanding of the GB terminology, a lot of time was spent explaining some of the wording to the respondents, which risked bias toward them answering the questions independently to reduce that bias, the explanatory questions were changed into ranking questions; and
ii. The findings could have systematic errors due to self-reporting and recall bias. However, the study endeavored to ensure internal validity and reliability by introducing a third component of the study, AHP, thereby validating the responses to the quantitative data.

3.19 Summary

Chapter Three described the research methodology. It included the sampling method and the data collection procedure. The study leaned towards the pragmatic paradigm, which allowed for a mixed method, culminated into a sequential mixed method design. Primary data was collected through a questionnaire survey and interviews with building professionals. The results of the two studies would be used to answer research questions.

The study's results are presented in Chapter Four. The chapter includes the findings from the analytical cross-sectional study. The findings are intended to address the study's aims. The data will show which variables are linked to the use of GBTs, the assessment method, criteria preference, and associated factors for the use of GBTs.

CHAPTER 4 PRESENTATION OF FINDINGS

4.1 Introduction

The study's research method was covered in detail in Chapter Three. It included both the sampling technique and the data gathering process. The study favored the pragmatic paradigm approach since it permitted the use of a variety of methods. The paradigm allowed for both constructivism and positivism ideology, thus the study method adopted was a sequential mixed method design. A questionnaire survey and interviews with building experts were used to gather primary data. AHP was used to analyze the data, and the findings from the two studies were used to illustrate the relationships between the study's variables.

In this chapter, results of the analytical cross-sectional study are presented. The knowledge and the associated factors to utilizing tools are provided in this chapter, whilst establishing the preferred methods and criteria for assessing green low-cost houses.

4.2 Questionnaire Survey Results

The questionnaire survey findings in this study addressed the research’s second, third, and fourth objectives: to determine the use and knowledge of GBTs in Zambia and define the ideal criteria for assessing green low-cost housing. The results included the respondents' socio-demographic information and experience and their preferred criteria for developing or evaluating GB. Descriptive statistics, correlation, and logistic regression (bivariate and multivariate) were used to analyze the data.

According to the study, 35 percent of the 115 respondents were from the Copperbelt area, while the rest came from Lusaka, Zambia's capital city. The respondents’ work experience ranged from 3 to 36 years, with a median of 12 years, as indicated in Table 4.1. The largest percentage of respondents (27 percent) have worked for more than 20 years. Female respondents made up 39 percent of the participants, while the rest were male (61 percent). Architects constituted 56 percent, quantity surveyors (QS) 17 percent, engineers and contractors were 10 percent, planners were 4 percent, valuation surveyors (VS) and developers were 2 percent.

Table: 4-1: Demographic and professional characteristics of respondents

Characteristic	Category	N. (%)		p-value
Years of experience	0-4 5-9 10-14 15-20 >20	20 (17.4%) 24 (20.9%) 23 (20.0%) 17 (14.8%) 31 (27.0%)		0.028
Gender (n=115)	Male Female	70 (61%) 45 (39%)		0.13
Profession (n=115)	Architects Q surveyors Engineers Planners Contractors V. surveyors Developers	66 (56%) 18.3 (17%) 11 (9.6%) 5 (4.3%) 11 (9.6%) 2 (1.7%) 2 (1.7%)		0.055
Projects undertaken.	residential nonresidential both Types	39 (33.9%) 26 (22.6%) 50 (45%)		0.05
Organization	Government Parastatal /quasi-Gov. Private	16 (14%) 15 (13%) 84 (73%)		0.067

Only 34 percent of respondents worked on residential building projects, while the rest worked on non-residential or both types. It was important to know how many were involved in housing projects to verify if actual green buildings strategies were being undertaken in the housing projects carried out by the respondents. The respondents came from the private sector, government, and parastatal companies, with the private sector accounting for 73 percent.

4.2.1 Utilization of green building strategies in housing development

As shown in Figure 4.1 demonstrates that 63 percent of the respondents had not used any of the selected GBTs. The most applied tool was LEED at 10 percent, trailed by BREEAM and ZSHG 7 percent. Green Star at 6 percent and SBAT at 4 percent and the least used tool being CASBEE, at 1 percent. The results on the level of awareness of GBTs in Figure 4.2 illustrates that of the 63 percent who had not utilized any tools, 50 percent of them had heard about them, 35 percent had read about GBTs, and 15 percent were not familiar with the tools.

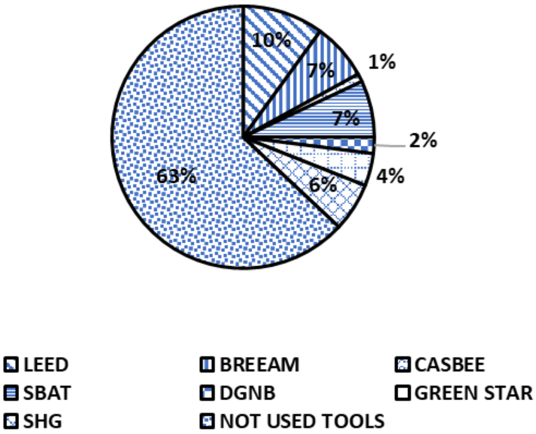


Figure 4-1: utilization of tools

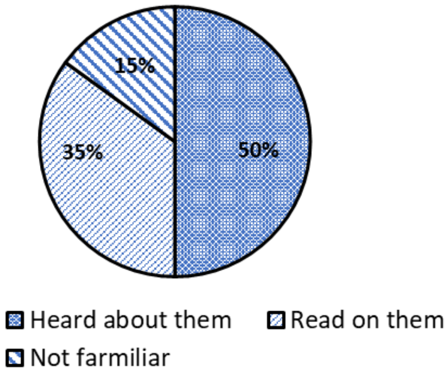


Figure 4-2: level of awareness of

The preference in the selection of tools Figure 4.3 highlights respondents' preferences for various types of GBTs. It shows that only 25 percent of respondents had gained knowledge from reading about GBTs, and 22 percent thought they were adaptable to the region. Those who thought the instruments were comprehensive enough to produce GBs were 57 percent, while 83 percent thought they were costly. The respondents that said the tools are accessible were 74 percent.

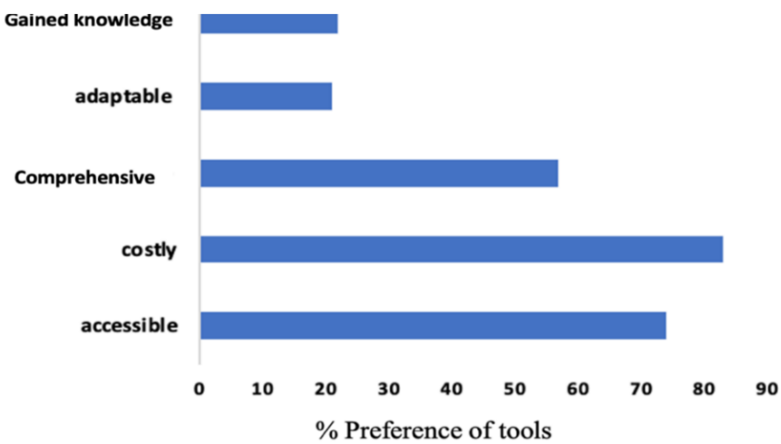


Figure 4-3: Preference of variables in GB strategies

4.2.2 The environmental criteria of green low-cost housing

The second objective of the study was to investigate the environmental criteria for assessing green low-cost housing development. Using the five-point Likert scale respondents were asked to choose the environmental criteria to use in development of green low-cost houses. The variables that were to be selected were derived from the conceptual framework and literature review. Preferences were assessed using a five-point Likert scale ranging from 1 to 5, with 1 indicating not important, 2, slightly important, 3, moderately important, 4, important and 5 very important. The results are as shown in Table 4.2.

Table 4-2: Environmental criteria for GB housing development

Enviro. Factors	**No. valid**	**Mean**	**Standard deviation**
Energy efficiency	115	4.60	.492
Health and wellbeing	115	4.04	.667
Material use	115	4.36	.776
Water efficiency	115	3.57	.889
Sanitation	115	4.00	.966
Solid waste management	115	3.43	1.051
Pollution	115	3.44	1.055
Sustainable site	115	2.51	1.015
Transportation	115	3.47	1.103

Energy had the greatest mean of 4.6, with the lowest standard deviation (SD) of 0.5, which was very close to the mean. Energy use low SD showed that the respondents felt it being the most important criteria to achieve green low-cost houses, followed by health and wellbeing (0.6). The mean for the other criteria ranged from 3.5 to 4.6 meaning the majority felt the criteria are important. Solid waste management, pollution, transport, and sustainable site having a mean of less than 3.5, with sustainable site having the lowest mean showed that these criteria were considered important but not very important. Material use, water efficiency, sanitation had SD that were high but less than 1, meaning more respondents agreed that the parameters were important but not very important. Pollution, sustainable site, and transport had means >3.5 and SDs more than 1 meaning the respondents' opinion was diverse, and they considered these factors moderately important but not the very important for green low-cost housing.

4.2.3 The social criteria for the development of green low-cost housing

There are social aspects that help attain green low-cost housing that were analyzed using SPSS to see which ones were considered very important. The respondents were asked to rate these social criteria using the Likert scale on a scale of 1-5 with 1 not important and 5 very important. The mean and the SDs were derived as seen in Table 4.3.

Table 4-3: Social factor for GB development

Social criteria	**No. valid**	**Mean**	**Standard deviation (SD)**
Security	115	4.80	.364
Accessibility	115	4.82	.497
Health facilities	115	4.33	.581
Education facilities	115	4.35	.582
Land tenure	115	4.13	.667
Social cohesion	115	3.89	.736
Recreation facilities	115	3.44	.844
Cultural freedom	115	2.55	.968

Healthy buildings in social sustainability means buildings that do not expose the occupants to biological or physical hazards had the greatest mean of 4.8 close to the maximum of 5 where the selection is a very important criteria, with the lowest standard deviation (SD) of 0.36. Healthy buildings with low SD showed that the respondents felt it being very important criteria when buildings are constructed with very little negative health challenges. This was followed by security (mean/ 4.8, SD 0.49). Security in buildings has been considered very important by the respondents due to the high crime rate in most communities. The mean for the other criteria ranged from 4.3 to 2.0 with the lowest preference being recreational facilities and cultural freedom. Cultural freedom had a (SD/1.16) meaning the opinion concerning this criterion was diverse among the participants.

4.2.4 The economic criteria for developing green low-cost housing

The economic liberty that comes from green low-cost housing is one of the pillars of sustainability. Therefore, in the questionnaire the respondents were asked to rate the economic criteria using the Likert scale on a scale of 1-5 with 1 not important and 5 very important. The mean and the SDs were derived using SPSS analysis as seen in Table 4.4.

Table 4-4: Economic criteria for GB housing development

Economic criteria	No. valid	Mean	Standard deviation (SD)
Efficient resource use	115	4.50	.494
Durable, resilience materials	115	4.42	.570
Local economic growth	115	4.43	.591
Local material production	115	4.25	.653
Skills training in GB materials	115	3.00	.983
Reduction of LCC	115	3.99	1.01

Table 4.4 shows that efficient resource use and durable, resilience materials had the highest mean and the lowest SD (mean=4.5, 4.4, SD= 0.5,0.6) respectively. The respondents felt that when resources are used efficiently it reduces waste and so the economic benefits are felt throughout the entire economy. Durable, resilience materials reduce the ultimate cost of housing as building last longer thus these were very important for economic sustainability. This was followed by local economic growth and local material production (mean=4.4,4.2, SD= .59, .65) that had SD less than 1 meaning the opinion of the respondents was not divergent and the criteria were considered important but not most important. Skills training in GB materials reduction of LCC had SD above 1 and the means were low, below 4. The last two criteria were considered slightly important but not very important. The reason the LCC was considered low could have been due to lack of understanding of what LCC is in green housing development.

4.2.5 The criteria selection using relative importance index

The research employed questionnaires to determine the preferred criteria for assessing low-cost green housing. Environmental, economic, and social criteria were considered based on a list of factors identified from similar studies (Berawi et al., 2019; Aquino et al., 2019). The Relative Importance Index (RII) is the mean score for an item adjusted to fall between 1/A and 1, where A is the total number of response categories and it was used to rank the preference from the Likert scale results in the questionnaire, as shown in Table 4.5. The respondents selected the criteria, and using RII formula in equation 4-1 and 4-2 the parameters were ranked as follows:

Equation 4-1

$$RII\ \% = \frac{5*(n5)+4*(n4)+3*(n3)+2*(n2)+1*(n1)}{5*(n1+n2+n3+n4+n5)}.$$

Where: n1, n2, n3, n4 and n5 = the number of respondents who selected:

n1= number of respondents who selected not important.

n2= number of respondents who selected slightly important.

n3= number of respondents who selected moderately important.

n4= number of respondents who selected important.

n5=number of respondents who selected very important.

$$RII = \Sigma W / (A * N)$$ Equation 4-2

Where W is the weighting given to each factor by the respondents (ranging from 1 to 5):

A is the highest weight (i.e., 5 in this case); and

N is the total number of respondents.

The higher the value of RII, the more important is the criteria in the assessment method. Energy had very important criterion (RII/0.93), followed by health and well-being (RII/0.911), and then material use (RII/0.81). Sustainable sites (RII/0.73) had a midpoint ranking of moderately important while Management (RII/0.60) was not important. The mean for the two methods, descriptive analysis and RII were similar for most of the criteria except sustainable site, waste management, economic and social. However, the differences were negligible with less than 0.2.

Table 4-5: RII preference of criteria of GB

Criteria	Very important (5)	importance (4)	Moderately important (3)	Slightly important (2)	Not important (1)	Total respondents (no)	Weighted total	RII	mean
Energy	85	20	10	0	0	115	535	0.930	4.652
Health and well-being	78	27	6	4	0	115	524	0.911	4.557
Material use	50	31	24	10	0	115	466	0.810	4.052
Water use	40	42	28	2	3	115	459	0.798	3.991
sustainable site	31	37	33	9	5	115	425	0.739	3.696
transport	23	40	36	8	8	115	407	0.708	3.539
waste management	20	45	17	14	19	115	378	0.657	3.287
economic sustainability	10	49	15	31	10	115	363	0.631	3.157
Social sustainability	12	35	25	28	15	115	346	0.602	3.009
Management	5	20	21	50	19	115	287	0.499	2.496

Figure 4.4 summarizes the preferences for assessment criteria from the 115 questionnaire survey participants, with over 75 strongly agreeing that energy use and health and well-being, should be highly prioritized in the GBTs and above 50 people preferred material use. A group of 40 to 50 respondents gave high ranking to water management, sustainable sites, transportation, and waste management. Between 5 to 10 people agreed that economic, social, and management should be prioritized.

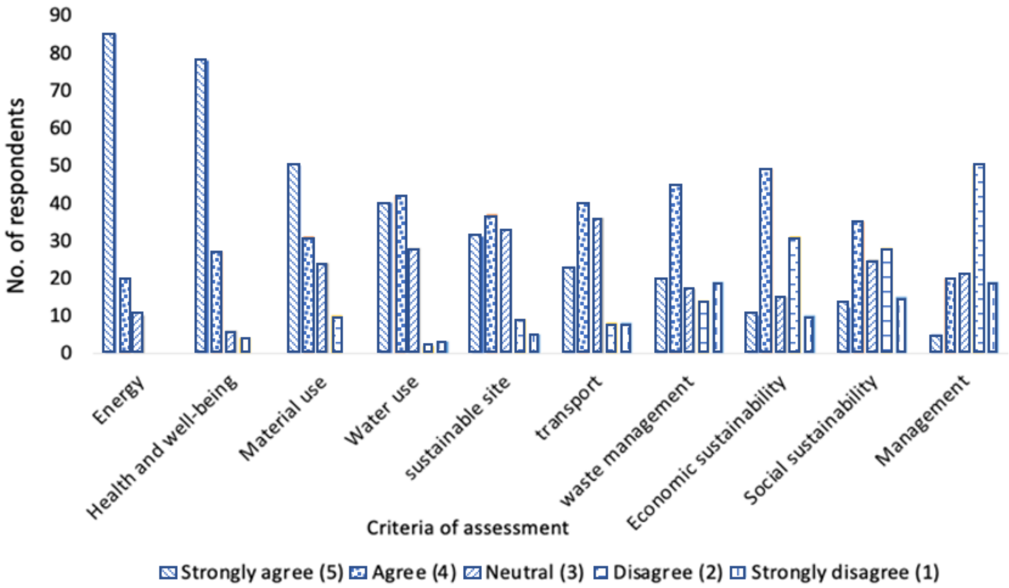


Figure 4-4: Respondent's RII criteria of assessment

Transport had the highest number of those who were neutral (40) about it being highly rated, followed by the sustainable site with 35 respondents being neutral.

4.2.6 The factors associated with the use of tools.

The third objective of the study was to investigate the factors associated with utilizing GBTs. A list of factors was presented in the questionnaire and the respondents were asked to rank them based on a 1-5 Likert scale, with 1 being the not important and 5 being very important. The factors were divided into four (4) groups (financial; governmental; environmental and cultural). The Likert scale findings were imputed into the RII formula to get the results, as shown in Table 4.6.

Table 4-6: RII factors associated with use of GBTs.

FACTOR RANKING	VERY IMPORTANT (5)	IMPORTANT (4)	MODERATELY IMPORTANT (3)	SLIGHTLY IMPORTANT (2)	NOT IMPORTANT (2)	TOTAL RESPONDENTS (NO)	WEIGHTED TOTAL	RII	ITEM MEAN
Financial									
Tax reduction of GB products	103	9	3	0	0	115	560	0.974	4.870
Providing economic incentives	77	24	10	4	0	115	518	0.901	4.605
Available green products and materials	83	14	13	5	0	115	520	0.904	4.522
Governmental									
Presence of regulations and policies	105	7	4	0	0	115	564	0.976	4.875
Government investments in GB	80	15	16	4	0	115	516	0.897	4.487
Improving multi-disciplinary collaboration	78	16	17	4	0	115	514	0.890	4.578
Environmental									
Environmental benefits in housing	106	8	2	0	0	115	566	0.979	4.876

Table 4-7: RII factors associated with use of GBTs. (Cont.)

FACTOR RANKING	VERY IMPORTANT (5)	IMPORTANT (4)	MODERATELY IMPORTANT (3)	SLIGHTLY IMPORTANT (2)	NOT IMPORTANT (2)	TOTAL RESPONDENTS (NO)	WEIGHTED TOTAL	RII	ITEM MEAN
providing green building innovation and certification	60	20	25	6	4	115	471	0.819	4.096
Reduced LCC	31	32	25	10	17	115	395	0.687	3.435
Cultural and market									
Improved market for green products and materials	57	21	22	10	5	115	460	0.800	4.000
High return on investment	54	20	25	11	5	115	452	0.786	3.930
Increasing property values	44	19	30	12	10	115	420	0.730	3.652
The interest of developers in GBTS	55	20	26	6	6	115	410	0.800	3.598
Publicity and campaigns on GBTs	11	15	18	46	22	115	295	0.513	2.465

The analysis identified the factors that have the greatest impact on Zambia's ability to build, green low-cost houses. The Likert scale was used to select their preference on 1 to 5 scale (1=not important, 2= Slightly important, 3= Moderately important, 4= Important and 5= very important). In the financial group the highest ranked factor was tax reduction of GB products (mean=4.9, RII=0.97) followed by providing economic incentives (mean=4.6, RII=0.91). These results were as high as those seen in the governmental group where presence of regulations and policies was ranked (mean=4.9, RII=0.98) and government investments in GB (mean=4.45, RII=0.89) were the highest factor. The highest in the environmental was environmental benefits in housing (mean=4.9, RII=0.98) which was as high as regulations and policies. In the cultural and market group, the highest was improved market for green products (mean=4.0, RII=0.8). The highest factor in the cultural and market was lower than other factors seen in governmental or environmental. The second highest factor in cultural and market was high return on investment (mean=3.9, RII=0.8). Environmental benefits of GBTs had the highest mean also close to the 5 maximum showing that it is a very important factor to achieve green low-cost houses. The lowest factor was publicity and campaign (mean=2.47, RII=0.51). The lack of attention for publicity and promotion may be caused by a lack of understanding of the advantages of posting data in an age where information is easily accessible online.

4.2.7 the analytical hierarchy process results

In this study an investigation is carried out to see which preferred rating tools could be used for assessing low-cost houses in Zambia. Three tools were considered (LEED, Green Star, and SBAT). The selection of these tools was based on preference in the region. LEED is the most used tool in the region, Green Star is being used in South Africa, SBAT is the tool developed in South Africa, therefore it was imperative to select these tools. The performance indicators were cost of assessment, environmental adaptability, knowledge gained from using the tools and comprehensiveness of the tools. A hierarchy development graph, displayed in Figure 4.5, was created to show the levels of preference and priorities in deciding on the criteria.

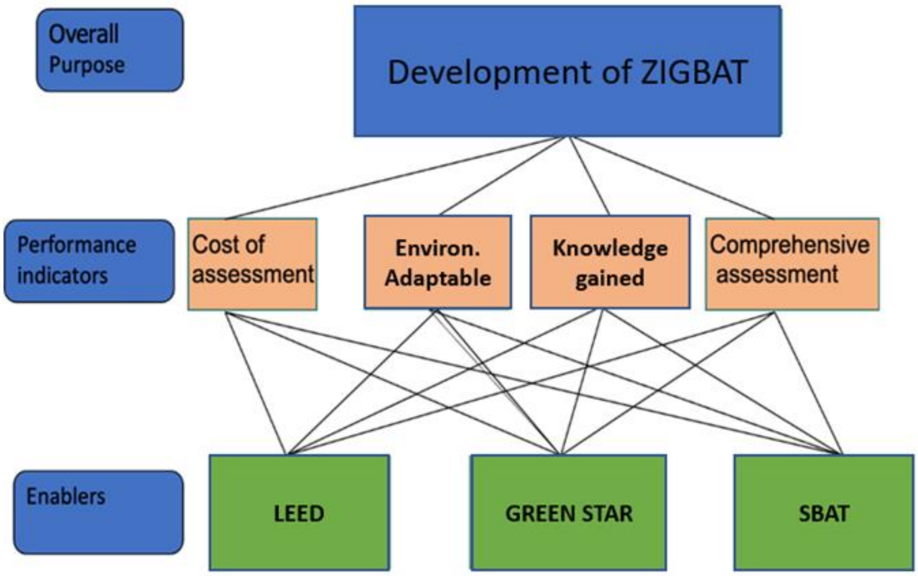


Figure 4-5: Hierarchy Development Graph

AHP tool was used to rank the selected performance indicators to create a GB assessment framework. The evaluators chose the approaches using a Likert scale of 1 to 5, with 1 denoting being not important and 5 denoting very important. The contribution of each parameter to achieving GBs is determined by the priority vector (or Eigenvector). The normalized matrix of the performance indicator using normalized arithmetic averages and the Eigenvector is shown in Table 4.7, with the maximum eigenvector being 4.1.

Table 4-8: Evaluators comparison of performance indicators

Performance indicators	**Cost of assess.**	**Knowledge gained**	**Enviro. Adaptability**	**Comprehensive**	**Criteria sum**	**Normalized Priority Vector**
Knowledge gained	0.14	1	0.17	0.125	0.31	0.13
Cost of assessment	1	7	3	0.2	0.89	0.22
Enviro. Adaptability	0.33	6	1	0.25	0.88	0.27
Comprehensive tools	**5**	8	4	1	1.13	0.38
4 max= 4.1	**Consistency Ratio (C.R.) =0.0370**					

The consistency ratio is used to assess the degree of consistency. If the ratio value exceeds 0.10, there is inconsistency in the judgments, therefore the results were consistent. The results on the performance indicators show that the most important variable in the use of the tools is comprehensiveness (priority vector/ 0.38) followed by if the tools are environmentally adaptable (priority vector/0.27). The least important was knowledge gained from the tools. It could have been selected very low due to the assumption that all the tools do give knowledge, or the evaluators felt that they already have enough knowledge about the tools.

Five evaluators responded to the invitation to rank the performance indicators. The result of the ranking is shown in Table 4.8. where percentage criteria weightage is calculated using TC AHP tool.

Table 4-9: Relative priority of performance indicators

Performance Indicator	**Evaluators**					**percentage criteria weightage**
	E1	E2	E3	E4	E5	
	(%)	(%)	(%)	(%)	(%)	(%)
Enviro. Adaptability	19.1	43.8	43.7	57.5	64.1	45.6
Comprehensiveness	49.4	33.1	35.1	26.6	15.3	31.9
Cost of assessment	22.1	18.2	14.1	7.3	13.7	15.1
Knowledge gained	9.4	4.9	7.1	8.6	6.9	7.4
Overall	100	100	100	100	100	100
Inconsistency	5.0	8.0	7.0	1.0	9.0	1.0

The overall evaluation of the performance indicators to select the best indicators showed that environmental adaptability of the method was considered the most important at 46 percent compared to the comprehensiveness of the method at 32 percent and cost of assessment at 15 percent and knowledge gained was the least ranked (7 percent).

4.2.8 The preferred tools for assessing green low-cost houses

The qualities and characteristics of GBTs are determined by the method and parameters of the assessment system. Five practitioners conducted a comparison to determine the most desired tool among LEED, Green Star and SBAT to evaluate green low-cost houses. Based on the practitioners' rankings, the pairwise matrix in Table 4.9 demonstrates that three of the evaluators ranked LEED higher than any of the other two tools and had the overall ranking

(46%). Two of the evaluators ranked Green Star higher than LEED while three of the evaluators ranked it lower. LEED was ranked by all the five evaluators higher than SBAT. LEED was 47 percent preferred than other tools, and Green Star was 35 percent more preferred than the other tools. SBAT is the least ranked may be because it has not been widely promoted and is known mostly by South Africa. LEED is a well-known tool perhaps its preference.

Table 4-10: Preference of assessment method from TC tool

Assessment Tool	**Evaluators**					**percentage criteria weightage**
	E1	E2	E3	E4	E5	Evaluation
	(%)	(%)	(%)	(%)	(%)	(%)
LEED	21.5	35.9	48.3	58.8	67.5	46.4
Green Star	50.6	42.8	31.9	30.5	19.3	35.0
SBAT	27.9	21.3	19.8	10.7	13.2	18.6
overall	100	100	100	100	100	100
Inconsistency	7.0	9.0	1.0	5.0	7.0	3.0

The summarized comparison between the performance indicators and the assessment tools on their perceived percentage contribution to achieving green low-cost housing is shown in Figure 4.6 below. LEED (63%) the largest perceived percentage contribution to having a comprehensiveness assessment, whereas it contributes the lowest to making the building cost effective. Green Star's highest contribution is that of knowledge (28%). SBAT had the highest score in cost effective (65%), knowledge (59%) and environmental adaptable at 56%, but comprehensiveness at 11%. LEED was only highest for being comprehensive at 63%.

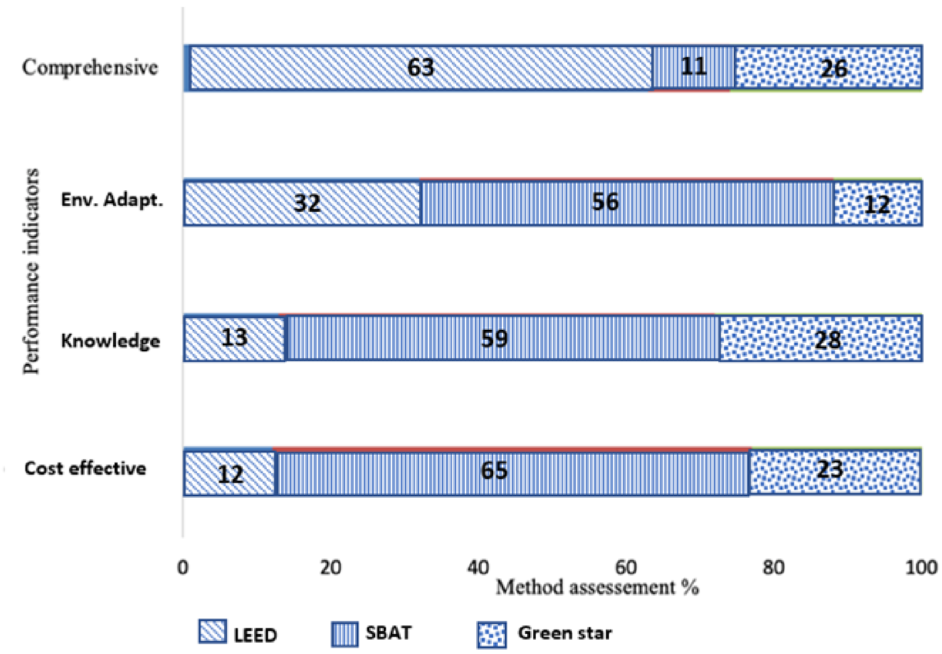


Figure 4-6: Comparison of performance indicators and assessment

4.2.9 Priority ranking for assessment criteria

The comparison study enabled the prioritizing of criteria that was considered suitable for use in green low-cost housing in Zambia. After coming up with the list of criteria the respondents were asked to rank the criteria according to preferences and then the results were further analyzed using AHP. Five purposively selected respondents who had scored highly in the knowledge GBTs questionnaire was asked to rank sixteen (16) criteria using the AHP transparent choice tool where the tool generates a weight for each evaluation criterion according to the decision maker's pairwise comparisons. The higher the weight, the more important the corresponding criterion. The contribution of each parameter to achieving GBs is determined by the priority vector (or Eigenvector). The analysis was undertaken to answer objective four (4) the identification and ranking of preferred criteria for assessment of green low-cost housing in Zambia. and to test the hypothesis that there are several criteria used worldwide to achieve GB development, however among the respondents there was no difference in the preference of what environmental, economic, and social criteria to be applied in the development of green low-cost housing in Zambi

Table 4-11: Ranking of GB criteria among the practitioners.

Eigenvector	**2.80**	**2.23**	**1.16**	**1.68**	**0.88**	**0.66**	**0.55**	**0.66**	**0.25**	**0.31**	**0.14**	**0.13**	
	Energy	Water	Mate.	Health	Sustain. site	Waste Man.	Trans.	Pollution	Economic	Education	Social Cohesion	Innovation	**criteria sum**
Energy	0.35	0.39	0.32	0.39	0.30	0.23	0.16	0.21	0.16	0.15	0.13	0.13	2.92
Water	0.07	0.20	0.24	0.26	0.24	0.19	0.14	0.21	0.14	0.13	0.11	0.12	2.06
Materials	0.09	0.07	0.08	0.04	0.12	0.12	0.12	0.17	0.13	0.12	0.10	0.10	1.25
Health and well being	0.12	0.10	0.24	0.13	0.18	0.27	0.12	0.17	0.13	0.12	0.10	0.12	1.79
Sustainable site	0.07	0.05	0.02	0.13	0.06	0.08	0.10	0.10	0.09	0.08	0.09	0.10	0.97
Waste Management	0.06	0.04	0.03	0.04	0.03	0.04	0.06	0.07	0.07	0.12	0.10	0.07	0.73
Transport	0.04	0.03	0.01	0.02	0.01	0.04	0.02	0.01	0.13	0.12	0.11	0.04	0.59
Pollution	0.06	0.03	0.02	0.03	0.02	0.02	0.10	0.03	0.13	0.10	0.11	0.10	0.76
Economics	0.04	0.02	0.01	0.02	0.01	0.01	0.00	0.00	0.02	0.03	0.07	0.10	0.35
Education	0.04	0.02	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.02	0.16	0.04	0.35
Social Cohesion	0.04	0.02	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.04	0.18
Innovation	0.04	0.02	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.15
Total	**1.00**	**1.00**											

Ranking the assessment criteria based on the literature and interview results. The criteria were used to assess the greenness of buildings at various stages of construction. Energy, water, materials, health and wellbeing, sustainable site, waste management, transportation, pollution, economy, education, social cohesion, and innovation were among the 12 criteria chosen, as shown in Table 4.10, based on the 5 evaluators. According to the eigenvectors or priority ranking, energy contributed the greatest at 28 percent, followed by water at 22 percent. Waste management and transportation were middle graded at 6 and 7 percent, with innovation coming in last at 1 percent. From these results the null hypothesis that there is no difference among the respondents which criteria they will choose for assessing building is rejected as the evaluators made specific preference.

4.2.10 Levels of knowledge of the respondents about green building tools

The respondents were asked questions in the questionnaire based on four GB principles (Concepts of GB, GB criteria, GB rating tools and external GB criteria). In the initial stages of analysis, descriptive statistics were used to find the mean and SD. The questions required a yes or no or not sure answer and each respondent was scored out of 10. There were 15 statements about GBs the mean was obtained from each group for every question and converted into the mean percentage. The mean percentage score was calculated for each question either architects or other professions. The score was 60% and above was high and below 60 was poor knowledge (Yusof et al. 2018; Shafei et al. 2012; Arbiol et al. 2016).

The respondents were divided into the two groups to test the hypothesis put forth as follows:

H_0: There is no significant difference in the knowledge levels of GB between architects and other professions.

H_1: There is a significant difference in the knowledge levels of GB between architects and other professions.

Table 4.11 shows a summary of the responses by respondents to various statements on environmental, and social-economic aspects of GB. The four statements were: green building concepts (CGB); green building practices (GB); green building tools (GBR); and external green environment (EGB). The total correct answers in the study population were compiled and the mean percentage and standard deviation (SD) of correct answers in each group were also tabulated.

When the two groups of architects and other professions were compared in knowledge level, both scored highly in CGB with a mean percentage greater than 70 percent. The architects (75-percent) responded positively to the statement that sustainable development is dependent on a complex interaction of environmental processes, culture, economy, and human activity, while the other professions responded fairly (60 percent, SD 1.01). In investigating the understanding of GB among the participants, four out of seven statements were answered very well by the architects (75-85 percent, SD < 1) while three out of the seven statements were answered correctly by the other professions (65-80 percent, SD >1). The results show that both groups had good knowledge of GB although there were differences among the two groups that were tested. As to whether HCFC or halogens found in some HVAC system do not affect the ozone layer was poorly answered by both groups (<70 percent, SD > 1).

The question on whether green fatigue is defined as a disease caused by living and working in "sick" or hazardous buildings were accurately answered by both groups (>70 percent) while the question of whether rain gardens, permeable pavements, vegetated roof, provide for stormwater infiltration with a significant p-value was better answered by the architects than other professions. Except for whether all rating tools require independent assessors to conduct the evaluation (65 percent), the architects answered all statements in GBR correctly and their p-values were significant (0.01). The other professions answered only one statement correctly at 85 percent while the rest scored 50 percent and the SD >1. The architects had more strongly agreed answers than the other professionals who said they were not sure.

Table 4-12: knowledge on green building tools

GB knowledge Statements	**A(Architects) (N=66)**		**OP (other professions) (N=49)**		**P-value**
	Mean %	**SD**	**Mean %**	**SD**	
Concepts of GB					
*The United Nations Env. Program see the issue of sustainable development as environment protection and resource-efficiency at least for our generation.	**85**	**0.58**	**75**	**0.96**	**0.075**
Maintaining biodiversity means maintaining the number and variety of living organisms	80	0.63	70	0.86	<0.05
Sustainable development relies upon a complex interaction of environmental processes, culture, economy, and human activity air quality	75	0.61	60	1.01	0.854
Green Buildings					
GBTs can maximize both the social-economic and environmental performance of buildings.	85	0.86	80	1.05	0.068
HCFC or halogens found in some HVAC system do not affect the ozone layer	60	1.22	55	1.41	0.054
*Indoor Air Quality (IAQ) refers to the air quality in buildings and not around buildings and structures	85	0.7475	65	0.85	0.753
Green fatigue is disorder from living and working in "sick" or toxic buildings	75	0.53	65	**0.83**	**<0.001**
Potable water can be replaced with grey water for landscaping irrigation					

Table 4-13: knowledge on green building tools (Cont.)

GB knowledge Statements	**A(Architects) (N=66)**	**OP (other professions) (N=49)**	**P-value**	**GB knowledge Statements**	**A(Architects) (N=66)**
	Mean %	**SD**	**Mean %**	**SD**	
Yes	85	0.74	80		
No	10		15	1.14	0.055
Not sure	0		5		
Green roofs provide temperature and sound isolation					
Yes	65		45		
No	35	1.05	42	0.86	0.058
Not sure	5		9		
In Rain gardens, permeable pavements, vegetated roof, provide for stormwater infiltration					
Yes	85		60		
No	13	0.54	28	0.79	0.045
Not sure	2		12		
GB rating					
*Green building cost more than traditional buildings					
Yes	75	2.15	50	**2.50**	**<0.05**
No	20		30		
Not sure	5		20		

Table 4-14: knowledge on green building tools(Cont.)

GB knowledge Statements	**A(Architects) (N=66)**	**OP (other professions) (N=49)**	**P-value**	**GB knowledge Statements**	**A(Architects) (N=66)**
	Mean %	**SD**	**Mean %**	**SD**	
The main criteria for assessment in GB are energy, materials, water, sustainable site, transport, health and well-being, pollution.					
Yes	90	0.47	65	**0.83**	**0.061**
No	5		24		
Not sure	5		11		
In all rating tools independent assessors are required to undertake the assessment					
Yes	65	1.25	50	**2.82**	**0.045**
No	23		30		
Not sure	12		20		
EGB					
*Heat Island effect is not generated from rooftops, parking areas, streets, and driveways?					
Yes	70	0.61	65	**1.48**	**0.047**
No	15		20		
Not sure	15		15		
Smart transportation include access to public transit			80		
Yes	95				

Table 4-15: knowledge on green building tools (Cont.)

GB knowledge Statements	**A(Architects) (N=66)**	**OP (other professions) (N=49)**	**P-value**	**GB knowledge Statements**	**A(Architects) (N=66)**
	Mean %	**SD**	**Mean %**	**SD**	
No	5	0.81		**0.98**	**0.021**
Not sure	0				
Having respect for cultural heritage is necessary for GB assessment.					
Yes	75		70		
No	5	1.12	4	**1.14**	**0.093**
Not sure	20		26		

4.2.11 Inferential statistics on knowledge test

The Mann Whitney test was used to further assess the significance of the indicators with mean values higher than 70 percent and statistically significant at p 0.05. The Mann Whitney *test* is a non-parametric examination of the null hypothesis. It compares differences between two independent groups when the dependent variable is either ordinal or continuous but not normally distributed. The dependent variable was knowledge about green building tools, and the independent parameter was the profession of the study population. The results are shown in Table 4.12.

Table 4-16: Mann Whitney test on knowledge levels of respondents

	N	Mean Rank	Sum of Rank	Mann-Whitney *test*	Z	Asymp. Sig.(2-tailed)
Knowledge Concept of GB (CGB) Architects Other professionals	65 46	54.91 57.54	3569.00 2647.00	1424.000	-0.427	.670
GB (GB) Architects Other professionals	65 46	62.23 47.20	4045.00 2171.00	1090.000	-2.496	0.013
Green building rating (GBR) Architects Other professionals	65 46	49.03 65.85	3187.00 3029.00	1042.000	-2.882	0.004
External GB (EGB) Architects Other professionals	65 46	55.65 56.50	3617.00 2599.00	1472.000	-0.142	0.887

Regarding the statement on CGB, the results show no significant difference in the knowledge levels between the architects (Median= 4, n=65) and other professionals (median =4, n = 46), U =1424.000, z=-0.427, p = .670 r =0.039. Hence, the null hypothesis is retained. For GB questions there were significant differences in knowledge between the architects (Median= 4, n=65) and other professionals (median =4, n = 46), U =1090, z=-2.496, p = 0.013, r =0.23) as the Asymp. Sig (2-tailed) value was .013, which is lower than 0.05. The null hypothesis was rejected. Because the p-value for GBR was less than 0.05, the knowledge was different (median =3, n = 65), U =1042.000, z=-2.882, p = 0.004, r =0.27) thus rejection of the null hypothesis.

Since the p-value was >0.05, the hypothesis that the two groups had similar knowledge for EGB was kept (median =4, n = 65), U =1472.000, z= -0.142, p = 0.887, r =0.082).

4.2.12 The association of the experience of the respondents and the utilization of tools

Categorical data were tested using a Pearson's chi-square test. It is employed to assess whether data significantly depart from the expectations. To determine if two categorical variables are connected to one another, the chi-square test of independence was used. The purpose of undertaking the analysis was to investigate whether the respondents experience in the building industry was associated with the use of GBTs.

The independent variables included gender, years of experience, profession, kind of organization, and type of tasks undertaken. Also considered were access to the tools, cost, adaptability, comprehensiveness, and knowledge of GBTs. Table 4.13 shows how data were presented using cross-tabulation tables.

Table 4-17: Correlation of GBTs use and experience of participants

Factors: Explanatory Variables	Utilisation of GBTs		Chi-square	*P-value*	Cramer's V
	Utilisation of GBTs n (%)	**Not utilizing GBTs, n (%)**			
Gender % (n=115)					
Male	83.7	82.4	χ^2 (1) =2.292	0.132	0.141
Female	16.3	17.6			
Experience % (n=115)					
$\leq$20	76.7	70.9	χ^2 (1) **=7.483**	<0.01	0.284
>=20	23.3	29.1			
Profession % (n=115)					
Architects	55.8	58.3	χ^2 (1) **=9.264**	**<0.050**	0.2408
Others	44.2	41.7			
Sector of employment % (n=115)					
Private	83.7	52.8	χ^2 (1) **=2.985**	0.050	0.161
Public	16.3	47.2			
Projects undertaken % (n=115)					
Residential	34.9	33.4	χ^2 (2) =0.187	0.889	0.255
Non residentials	11.6	29.1			
Both types	53.5	37.5		1	
Access to GBTs % (n=115)					
Accessible	74.4	51.4	χ^2 (1) =2.985	0.968	0.109

Table 4-18: Correlation of GBTs use and experience of participants (Cont.)

Factors: Explanatory Variables	**Utilisation of GBTs**	**Chi-square**	***P-value***	**Cramer's V**	**Factors: Explanatory Variables**	**Utilisation of GBTs**
	Utilisation of GBTs n (%)	**Not utilizing GBTs, n (%)**				**Utilisation of GBTs n (%)**
Not accessible	25.6	48.6				
	Cost of GBTs % (n=115)					
Costly	83.7	51.4		χ^2 (1) **=5.634**	**0.05**	0.221
Not costly	16.3	48.6				
	environmental adaptability **% (n=115)**					
Adaptable	20.9	40.3		χ^2 (1) **=40.807**	**0.043**	**0.596**
Not adaptable	79.1	59.7				
	Comprehensive tools % (n=115)					
Comprehensive	53.5	51.3		χ^2 (1) **=1.390**	0.860	**0.110**
Not comprehensive	46.5	48.7				
	Knowledge about tools % (n=115)					
Knowledgeable	81.3	33.3		χ^2 (1) **=23.596**	**<0.001**	**0.474**
Not Knowledgeable	18.7	66.7				

The following variables were statistically significant: profession, type of organization, cost of green tools, environmental adaptability, and knowledge. For the relationship between profession and utilization of tools, the study compared two groups, architects, and the other professionals in the study population, to see which group was more likely to utilize the tools. The percentage of architects who utilized the tools was higher than all the other professions, recording 56 percent. The Chi-square test of independence showed this association (X^2 (1, N= 115) = 9.264, p<.05). For the direction of this relationship, the Cramer's V value of 0.2408 revealed a positive weak to moderate association.

The private sector had more participants, with 84 percent having used the tools, than public entities. The relationship between usage and organization was statistically significant (X^2 (1, N = 115) = 2.985, p.050). Cramer's V value of 0.161 was a positively weak association between the explanatory variable of the employment sector and the outcome variable utilization of GBTs. For those who had utilized the tools, there was a positive weak association with Cramer's V value of 0.221 between the cost of assessment and utilization, (X^2(1, N= 115) = 5.634, p<.050). If respondents felt that the tools were adaptable, there was an association with utilization of the GBTs (X^2 (1, N= 115) = 40.807, p< .05), and the Cramer's V value of 0.596 showed a positive, moderately high correlation. The correlation between tool use and knowledge was statistically significant (X2 (1, N = 115) = 23.596, p.05), and Cramer's V value of 0.474 showed a moderately high positive relationship. In this study, the null hypothesis that there was no significant link between tool use and the independent factors was rejected.

4.2.13 Regressing utilization of tools with experience variables

A binary logistic regression was used to identify participants characteristics linked with the usage of tools GBTS. The outcomes were compared between two groups of people: those who used the tools and those who did not. The outcome variable in this study was a binary outcome. A Yes meant they had used the tools, but a NO meant they had not used the tools. All the variables used in the Cramer's V correlation test were included in the tool (profession, type of organization, type of projects undertaken, cost, relevance, and knowledge of GBTs). The results of the test are shown in Table 4.14.

Table 4-19: Coefficient of GBTs and experience of participants

Covariate	**N**	**Coefficient**	**Standard error**	**Odds ratio**	**95% confidence Interval**	**P-Value**
Gender						
Male	95			(Ref)	(Ref)	(Ref)
Female	20	0.427	0.591	1.533	0.481-4.885	0.470
Years of experience						
<20	84			(Ref)	(Ref)	(Ref)
≥=20	31	1.034	1.488	2.813	0.152-14.452	0.024
Organization						
Public	41			(Ref)	(Ref)	(Ref)
Private	74	0.687	1.282	1.988	0.161-24.517	0.065
Profession						
Other professionals	49			(Ref)	(Ref)	(Ref)
Architects	66	1.360	1.279	3.896	0.318-24.768	0.031
Type of projects						
Residential	30					
Residential and non-residential	85					
Cost						
No	17			(Ref)	(Ref)	(Ref)
Yes	98	-1.958	0.605	0.141	0.043-0.462	**0.015**
Adaptable to environment						
No	78			(Ref)	(Ref)	(Ref)
Yes	33	1.393	1.349	4.028	0.286-27.625	<0.001
Knowledge about tools						
No	44			(Ref)	(Ref)	(Ref)
Yes	69	0.962	0.270	1.78	0.432-1.492	0.068

With a regression coefficient of 1.034, there is a statistically positive relationship between years of experience and tool use. The probabilities of using the tools increase thrice for everyone (1) unit increase in years of experience. As a result, the null hypothesis of no association was rejected. Although the regression coefficient for the type of organization was .687 and the odds ratio was 1.988, the p-value was >0.05, thus the null hypothesis that there was no association between use and type of organization was retained. There was a significant relationship between the predictor variable utilisation and the kind of profession, with a positive coefficient of 1.360 and an odds ratio of 3.896. If one is an architect, the chances of using the tools were four times higher than if one was not an architect hence the null hypothesis is rejected for no relationship. Those who thought the cost of certification to be too high had a lower odds ratio of 0.141 and a negative (-1.958) regression coefficient. The likelihood of using the tools decreased the more the respondents felt that the rating tools were expensive. With a regression coefficient of 1.393, there was a positive relationship between tool environmental adaptability and utilisation. There was a four-fold rise in the probabilities of the tools being used for every unit increase in environmental adaptability. Hence, the null hypothesis was rejected for no relationship. The other variables of gender, organisation and knowledge were not statistically significant, and their respective null hypotheses were retained.

4.2.14 The regression for factors association with the use of green building tools

To answer the third objective on the association of factors with the use of GBTs in low-cost housing, a hypothesis was constructed that there is no association between the selected factors and the use of GBTs among the respondents.

A logistic regression analysis was undertaken, it predicts the probability that an observation will fall into one of two groups of binary dependent variables. There are one or more independent variables, either continuous or categorical, that are tested. The outcomes were compared between two groups of people: those who had experience on GBTs and those who did not. The outcome variable in this study was a binary outcome. A Yes meant they had experience, but a NO meant they had no experience. The growth of green low-cost housing was the dependent variable, and the independent variables were those derived from the problem tree diagram and literature such as high cost of assessment, green materials, technical knowledge, education on GBTs, government byelaws, green building strategies, public interest, and lack of interest for GBTs. The regression has been run as shown in Table 4.15. There are two columns, one for unadjusted and the other for adjusted estimates. The unadjusted results relate to correlation and do not consider possible confounders management, education, or recreation. The adjusted estimates show that the remaining variables were not confounders in the prediction since the adjusted odds ratio did change significantly.

The variables that were statistically significant with a P-value less than 0.05 were; (cost of assessment/ OR=3.339, 95% CI; (0.821-14.452); P=0.048; training on GBTs / OR=0.151, 95% CI; (0.029-0.793); P=0.039); high return on investment / OR=2.8, 95% CI; (0.86-0.97); P=0.045; economic incentives /OR=2.573, 95% CI; (1.640-12.05); P=0.05 and sustainable building byelaws/ OR=4.431, 95% CI; (1.754-13.03); P=0.040. From this analysis it shows that there is 3 times increased odds to select cost of assessment. Training on GBTs was statistically significant but there was no increase in the odds to choose GBTs based on one being trained or not. High return on investment has an increased odd of 3 times to use the tools if they were high returns on investing in GBs. Economic incentives were significant, and the odds increased by 3 times of selecting GBTs if there are incentives in GBs. For public interest, there was no increased odds for it being a factor for the growth of green low-cost housing. Technical knowledge and sustainable building byelaws (OR=3.659, 95% CI; (1.282-10.444); P=0.049; OR=4.431, 95% CI; (1.754-13.03); P=0.040) has a 4 times highest chance of influencing the emergence of green low-cost housing for the group that had experience in GBTs. From the results the null hypothesis is rejected as there are significant factors associated with the use of GBTs in Zambia's low-cost housing.

Table 4-20: Regression of factors associated with the use of GBTs

	Unadjusted Estimates			**Adjusted Estimates**		
Variable	OR	(95% CI)	P-value	OR	(95% CI)	P-value
Cost of assessment Yes No	Ref 3.639 0.961	 (0.911-14.542) (0.939-0.983)	 <0.048 0.25	Ref 3.339 0.901	 (0.821-14.452) (0.873-0.878)	 <0.049 0.67
Training on GBTs Yes No	Ref 0.241 2.58	 (0.041-0.883) (1.00, 6.67)	 0.025 0.051	Ref 0.151 1.93	 (0.029-0.793) (.970, 5.85)	 0.039 0.072
Technical knowledge Yes No	 0.976 *3.789*	 (0.989-14.515) (0.350-1.204)	 *<0.043* 0.1470	 3.659 0.881	 (1.282-10.444) *(0.260-1.147)*	 0.049 *0.981*
High return on investment: Yes No	0.93 7.004	(0.96-1.08) (2.279-21.552)	0.013 0.074	2.8 0.401	(0.86-0.97) (0.129-43.35)	0.045 0.0127
Tax reduction of GB Yes No	Ref 3.60.5 0.544	 (1.31, 9.92) (0.191, 1.546)	 0.042 0.001	 2.368 0.850	 (0.75, 7.24) (0.127, 1.270)	 0.057 0.068
Economic incentives Yes No	Ref 4.944 0.151	 (1.77, 13.86) (0.029-0.793)	 <0.043 0.61	Ref 2.573 0.289	 (1.640-12.05) (0.059-0.9107)	 <0.050 0.681
sustainable building byelaws Yes No	Ref 3.544 0.241	 (1.53, 12.78) (0.025-0.891)	 <0.064 0.75	Ref 4.431 0.167	 (1.754-13.03) (0.069-0.8200)	 <0.040 0.549

4.2.15 Analytical hierarchy process ranking factors associated with green building tools

There are several criteria used worldwide to achieve GB development, however among the respondents all the available criteria could be applied in the development of green low-cost housing in Zambia. The criteria were divided into three groups (Environmental, economic, and social criteria). After the AHP analysis the results were tabulated as shown in Table 4.16. The highest ranked criteria were Energy (20%), followed by water management (12%), and health and wellbeing (11%). This means that energy contributes 20% to achieve green low-cost housing, water management 12% and health and wellbeing 11% and material use (9%). In the social criteria the highest was security (7%) which means people feel secure outside and inside their homes, followed by facilities development (4%), which entails the buildings of hospitals or schools in the neighborhood to reduce on mobility. The lowest was social cohesion (1%), it is achieved when people interact with each other and the environment easily. It could have been selected low due to lack of understanding of its purpose in GBTs. Durability and resilience rank highest in terms of economic criteria; it refers to the use of materials in GBTs that will endure over time and be resistant to the effects of climate change. Local production of goods and services and resource recycling came in second at 4%. There was a significant difference in ranking for durability and resilience with the other criteria in the group. Although it is significant in GBTs, biodiversity received the lowest ranking, which may be related to a lack of knowledge about its significance in achieving environmentally friendly low-cost housing.

Table 4-21: Ranking of GB criteria among the respondents

Criteria	**Normalized Score**	**Eigenvector**	**Criteria weight %**	**Ranking**
Environmental				
Energy	0.15	2.00	20	1
Water	0.13	1.20	12	2
Health and well being	0.08	1.10	11	3
Materials	0.07	0.9	9	4
Sustainable site	0.06	0.8	8	5
Pollution	0.06	0.4	4	7
Waste Management.	0.05	0.4	4	7
Transport	0.02	0.20	2	8
Social				
Security	0.07	0.7	7	6
Social Cohesion	0.02	0.11	1.1	9
Recreation	0.02	0.22	2.2	8
Facilities development	0.06	0.4	4	7
Economic				
Durability and resilience	0.07	0.9	9	4
Local production and employment.	0.06	0.4	4	7
Resource recycling	0.06	0.4	4	7
Biodiversity	0.02	0.005	0.5	10

After scoring the criteria those that had highest ranking from each group were used in the next level of analysis. The scoring of the variables with the criteria was necessary due to the challenges outlined in literature such as poor resource utilization and technological knowledge on GBs. To perform the evaluation using the AHP Transparent Choice tool, four evaluators were chosen from those who obtained high knowledge scores in the questionnaire on GBs. The results have been normalized using the tool. AHP tool enabled the selection of multiple criteria across various groups and generated results based on the choices. Table 4.17 summarizes the findings. The analysis investigated which criteria were easy to use, environmentally adaptable, the cost of implementation was low, and its contribution to making the building green. Energy had the highest ranking (0.175) for the contribution to making the building green, followed by water while security had the lowest input (0.021).

Table 4-22: Ranking of criteria against performance indicators.

Performance indicators	**Highest contributor to green bld.**	**Cost of green implementation**	**Enviro. Adaptability**	**Easy to achieve in green bld**	**Geometric mean**
Water	0.162	0.026	0.504	0.475	**1.167**
Security	0 0210	0.113	0.475	0.511	1.12
Durability & resilience	0.0385	0.029	0.502	0.304	0.8735
Facilities develop.	0.330	0.091	0.068	0.268	0.757
Energy	0.175	0.025	0.081	0.025	0.306

Security had the highest ranking for cost of implementation of green strategy (0.113), followed by facilities development (0.091) and the least contributor was energy (0.025). In environmental adaptability the highest was water management (0.504), followed by durability and resilience and the least was facilities development. To determine which criteria was easy to adapt to the buildings, security was at the top (0.511), followed by water management (0.475) and the lowest was energy use. When the overall mean was calculated the most preferred criteria based on the performance indicators was water. These findings demonstrate that although energy was regarded as the most favored criterion, it is not necessarily the most preferred when it is chosen based on other factors.

4.3 Qualitative Results

The qualitative study key informants were purposively selected from the study population. All who had used GBTs and held decision making positions in their respective institutions were selected. Only 10 people out of a target population of 20 took part in the interview. The main emphasis of the discussion was GBTs, and the theme questions used in the interview were derived from the questionnaire survey results, as shown in Table 4.18. Use, knowledge, experience, cost, policies, and factors to GBTs use were the themes.

Table 4-23: interview themes

Utilization	Knowledge	Experience	Challenges	Policies	Factors
Not familiar	Literature	Available tools	High cost on buildings	Building bye laws	Polices/ regulations
Access	Training	Practice	relevance	Government polices	Cost of GB
Clients/ developers' interest	Opportunity	Affordability of tools	skills	Environmental laws	Technical
Availability of tools	Experience	Promotion	Affordability	Promotion of GB	Training
Relevance	Availability of tools	Applicable to the industry	Available tools	Regulating green building development	Tax reduction of GB

4.3.1 Utilization of green building tools

Although all the key informants said they had used GBTs, most of them were third-party users, and the principal assessors were usually from outside the country. The use of tools was contingent on funding and was not initiated by the architects. As one respondent said: *"We do not identify with these assessments because they are not our ideas, they come from outside and are imposed on us* (KII-7)."

Some of them noted that a few professionals had completed an evaluation on their own, but the bulk of them said that the tools were too expensive and that they lacked the technical skills to do the assessment. They believed that because of the high expense of assessment, most clients or developers regarded it as a luxury to include in a construction project as one said:

> *"It is not often that issues of GB are discussed and so I as an architect I do not usually discuss that with my clients because I assume that they would not be interested in taking on extra cost on projects* (KII-1)."

4.3.2 Uses of the various green building tools

The key informants were questioned about their knowledge of GBTs. Some stated that they were familiar with building assessments and had participated in them. Some had used the tools due to their client's request. Those who had employed BREEAM, LEED, Greenstar, and BIM in public projects had done so because it was planned. The criteria in the SBAT tool were not used to rate the building, rather, they were intended to guide the design and construction process. They asserted that clients mostly funded the use of tools as captured in the response hereunder:

> *"The reason we ended up using the LEED tool was that it was part of the project objectives, and the assessment was paid for, thus it was easy to use it and we did not incur any extra cost that was not budgeted for* (KII-6)."

Concerning their skills to perform an assessment, six described how the tools work and what they constitute. Eight key informants knew only one GBT, whereas two had knowledge of multiple GBTs. Those who knew more than one GBT were able to point out the differences and similarities between them. As one informant put it, they were able to illustrate the criteria and grading in each GRT.

> *"LEED, BREEAM, and Greenstar are easy to compare as their scores are very similar and the criteria found in the tools are similar as well* (KII-1)."

Those who were familiar with SBAT and ZSHG said they were suited for the region because they considered national factors. They explained that, even though SBAT and ZSHG were not established as assessment tools, they considered them acceptable because they factored in characteristics such as solar energy, water harvesting, thermal comfort, and local materials.

4.3.3 Experience in designing and constructing green buildings

The discussion on their diverse green building solutions, that green building methods were incorporated into their designs or construction projects. According to one account, GB was demonstrated by employing local building materials. But they were quick to state that:

> *"Real sustainability will only be achieved if the building materials we are using are cheap to manufacture and locally produced* (KII-3)."

When asked if experts in the building sector were using green building techniques, three indicated they did, while seven said very few did. As one informant who spoke about the usage of green building strategies in projects put it:

> *"It is slow, but most designs are done by qualified architects, these people consider elements of sustainable buildings such as having natural ventilation, lighting, water conservation and reuse of greywater. It is slow because the materials used are not locally produced and I think we still have a long way to go* (KII-2)."

Another informant noted that there were few green structures to illustrate that green building principles were being followed but was quick to add that the experts' perspective was shifting toward doing so. Despite the current problem, it was claimed that the construction industry was steadily adapting to ecologically friendly structures. They gave examples of Zambians employing hydra form blocks in building construction as one option. The challenge was the difficulty to find cheaper buildings materials with low embodied energy.

4.3.4 Challenges in using green building tools

The key informants explained that their main challenge in utilizing GBTs was a lack of experience and technical knowledge about the tools. They mentioned that there was little information concerning tools reaching them within the country, and one of them said:

> *"In Zambia, there is very little publication on the level of utilization of various assessment tools and not a single assessment tool has been adopted officially for use in Zambia. The use of GBTs is new in Zambia, with very few professionals having used any assessment tools in their work* (KII-6)."

Some key informants mentioned that it was a challenge to use the GBTs as there were differences in criteria and the scoring in the tools. Those that had used the SBAT tool felt that it lacked the scoring process as seen in BREEAM or LEED. Others felt that the SBAT was more realistic with the criteria that its uses than the other tools like BREEAM or LEED as stated here:

> *"The criteria in the current rating tools are not adaptable to the local environment, therefore they cannot give a true value of our GB achievements and the social, economic, and cultural criteria found in SBAT is more applicable to the African context and particularly the issues of sustainability in the Zambian context than other tools like LEED and BREEAM. The tools must be customized for Zambia, the copy*

> *and paste tools will not work because they are designed for other environmental conditions* (KII-8)."

Due to the differences in the tools, it was felt that assessments done with the LEED tool could not be compared to the other GBTs on all criteria. According to one informant, choosing an instrument suitable to the Zambian environment was challenging as expressed hereunder:

> *"The scores in LEED for energy were much higher than tools like BREEAM which has a lower score. This can be a challenge when one is comparing two similar buildings scored by different tools and the rating results could differ* (KII- 1)."

Another issue raised by the key informant was that in most of these initiatives, the customers picked the kind of GBT to utilize, and the experts were not the primary implementers. The key informant felt they lacked the expertise to rate buildings due to poor knowledge.

Asked why they had not used the SHG, two of the key informants mentioned that they were not aware of its existence, while one informant mentioned that they could not use it as it was limited in scoring and certification of green building criteria. Three respondents mentioned that the information in the document was difficult to apply to the real-life project due to a lack of knowledge on the use of the same guidelines. Professionals are not obligated to use the principles stated in the SHG, according to another responder, because there are no bylaws or policies on the use of GBTs in Zambia.

4.3.5 Policies and guidelines for green buildings

When the key informants were asked if there were any policies and guidelines for GB, none of them was aware of them. They mentioned that existing policies like the building bylaws meant to help them build in a green way lack specific GBTs. The respondents felt the need to have specific regulations to direct designs and construction projects as one of them said:

> *"We need regulations that will govern how we construct our buildings so that even developers and clients can follow these rules making it easier to finance the greening of building projects, you see clients are the main contributors to the assessment of buildings, so they cannot be left out and they need to appreciate the importance of greening our buildings* (KII-9)."

The key informant agreed that the building bylaws and regulations were not meeting the changing environment that require architects to consider several aspects of materials, site, and social-economic environment in a sustainable way. They went further to mention that the regulations even went against the championing of green building principles, in that some laws prohibit the use of green materials such as wood and clay bricks.

4.3.6 Factors associated to utilizing green buildings tools

Several factors associated with utilizing GBTs were identified. These included the absence of bylaws and policies specifically for GB, lack of technical knowledge, and absence of players interested in green building compliance.

4.3.6.1 Lack of regulation and policies on green building tools

The key informants complained that the government was not taking a leading role in promoting green building compliance, hence low adherence. Concerning the absence of bylaws as a contributing factor, one informant said:

> *"There are no policies and building bylaws to govern the development of assessment tools and there are no incentives to use GBTs in Zambia. The other barrier is a lack of client's interest in using GBTs as they feel that the cost of the assessment is too high* (KII-6)."

According to the key informant, the law does not allow the use of clay or wood as a wall material in urban areas, and this is how policies are not supporting the greening of buildings. They mentioned the need for political will and policy direction through the government. Some of the key informants stated that developers and clients were not enthusiastic in assessing the greenness of their buildings thus funding was not made available for GB rating.

Regarding the factors associated with utilizing the SHG, two of the key informants mentioned that they had not even heard about the guidelines, while the rest felt there was a lack of publicity. Some pointed out that the format of the guidelines was inhibiting as it was not designed as an assessment tool but as a guide.

4.3.6.2 High cost of assessment

Apart from factors like lack of policy and bylaws in sustainable buildings, the respondents mentioned that they were hindered by the high cost of training and assessment, and they preferred cheaper and user-friendly tools.

4.3.6.3 Lack of technical knowledge

The lack of technical knowledge was seen as an associated factor in the use of tools, as most key informants mentioned that they could not afford to be trained as assessors. They lacked technical skills to undertake assessments due to poor transfer of knowledge and access to training was very expensive as expressed by one informant:

"I would like to be trained as an assessor, but the opportunity has not come my way to get access to these programmes as I am aware that it is very expensive to acquire this training. I think the challenge is that we have not prioritized the training of assessors in GB as part of our continuous professional development (KII-3)."

4.3.6.4 Regulations and policies on green building tools

Another informant indicated the need to introduce sustainable building laws that would promote the development of local assessment tools for the Zambian building industry, as stated below:

> "*There is need to use cheaper and user-friendly tools, train both skilled/unskilled labour including occupants. Government policy should promote the use of assessment tools and recognition and reward organizations utilizing assessment tool* (KII-7)."

All the key informants agreed that government intervention was key to driving the utilization of GBTs in the Zambia building industry. They stated that enforcement of laws that govern GB was cardinal if such new technology was to be implemented. The other challenge was that most clients and developers found rating buildings a luxury. However, some are coming to recognize the need to assess their structures as evaluations raised the building's worth.

4.3.6.5 Developers and clients promoting the use of green building tools

Other major motivations were the developers' and clients' interest in the assessment and their ability to pay for it. According to the key informant, if the users of the buildings take the lead in promoting the usage of GBTs, experts will naturally use the tools. It was claimed that a professional's expertise and skills in using GBTs should motivate clients to recognize the advantages of using the tools.

4.3.6.6 Environmental, social- economic effects of buildings

Another source noted that confirmation that GBTs can assess building greenness is a motivator because it demonstrates green construction's environmental, social-economic benefits. As previously noted, another impetus was the advantage of health and wellness in GB as expressed below:

> *"The proof that GB can reduce the negative environmental and social- economic effect of buildings makes it a key factor and clients want to see that the buildings are improving the health and wellbeing of their tenants and that building materials and components do not cause harm* (KII-10)."

4.4 Summary

The chapter presented an analysis of both questionnaire survey and interview results. The utilization level of GBTs was 37 percent, with the highest being LEED at 33 percent. Years of experience, the profession of the respondents and type of organization influenced the utilization of GBTs. There was a statistically significant link between GBTs use and the variables of knowledge, cost, and adaptability of tools.

Chapter Five outlines the development of ZIGBAT. The method and the process of development of the Tool were explained earlier. The ZIGBAT was developed as a planning tool to attain GB compliance and it has ten assessment criteria. The AHP tool was used to develop the framework, where the selection of the assessment criteria is based on preference ranking. The computer programme used in developing ZIGBAT was an integrated system adapted from CASSUD framework. The program was validated through feedback from experts.

CHAPTER 5 ZAMBIA INTEGRATED GREEN BUILDING ASSESSMENT TOOL

5.1 Introduction

The results, interviews, and AHP evaluation were presented in the previous chapter. Only 37 percent of respondents had used the rating tools. However, the utilization of LEED accounted for the highest users at 33 percent. Years of experience, the profession of the respondents and type of organization, influenced the utilization of GBTs. There was a statistically significant link between GBT use and the variables of knowledge, cost, and environmental adaptability of tools. The preferred criteria for assessment showed that more than 60 percent of the respondents strongly agreed that energy use, materials and health and well-being should be highly scored in the GBTs. The lack of GB regulations and policy, cost and a lack of technical knowledge were the factors discussed in the interviews.

Accordingly, this chapter presents the Zambia Integrated Green Building Assessment Tool (ZIGBAT) development. It was developed as a planning tool to attain GB compliance. It has 8 assessment categories. The evaluation parameters were chosen based on the AHP preference ranking outputs from the questionnaire survey and the outcomes of the interviews and the selected GBTs. The ZIGBAT is a computer tool based on the Comprehensive Assessment System for Sustainable Urban Development (CASSUD) framework. The evaluation tool is intended for use in both the development and assessment of green low-cost housing. Expert feedback was used to validate the Tool.

5.2 Tool Development

Tool development is necessitated by the changing expectations and goals of users who require appropriate tools to reduce the negative impact of buildings on the environment. These instruments are developed according to environmental and social-economic parameters set in a particular region or country (Anshebo et al., 2022; Basten et al., 2019). The development of new GBTs must consider the potential for renewable energy gain, geographical characteristics, resource consumption, government policies, availability of raw materials, technical knowledge, and appreciation of historical value (Liu et al., 2022; Amasuomo et al., 2017; Nguyen & Macchion, 2022). Assessment tools do not remain static, they evolve depending on the needs. Studies by Amasuomo and Astanda, (2017), and Ali and Nsairat, (2009) seem to point to adapting parameters or criteria from other rating tools rather than creating new tools. Adaption of old criteria may depend much upon the expectation of the users. Some of the criteria found in GBTs may just be right for a particular environment or may not be suitable. There are basic criteria that could apply across the board, but each region has unique characteristics that need to be included in tools to make them appropriate for use. Studies like Amasuomo and Astanda, (2017) and Ali and Nsairat, (2009) all seem to point to adapting parameters or criteria from other tools rather than creating new ones.

5.3 Process of Developing the Tool

The first stage of tool development is drafting either new or adapted goals or defining items that would be considered criteria, as shown in Figure 5.1. The selection should involve expert knowledge and scientific research, and this could either be building professions or independent assessors. Each item must be defined, and the context from which the item is selected must be given. The tool undergoes an evaluation to see whether it works according to the goal.

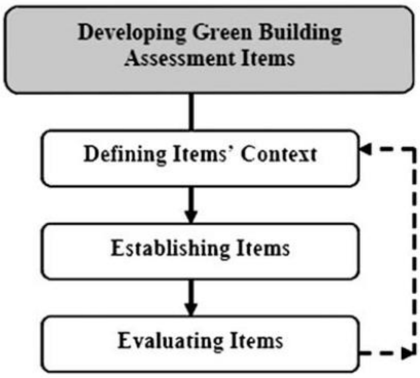


Figure 5-1: Development of GB assessments
(After Ali and Nsairat, 2008)

The World Green Building Council recommends the ISO 9001 quality assurance framework which looks at the Plan-Do-Check-Act, methodology as shown in Figure 5.2. The methodology emphasizes the need for rating tools to be developed with the end-user in mind. Therefore, set objectives should drive the process and the purpose of assessment should influence which objectives are set. The third stage is a robust check and measurement of the performance and whether it has met the objectives.

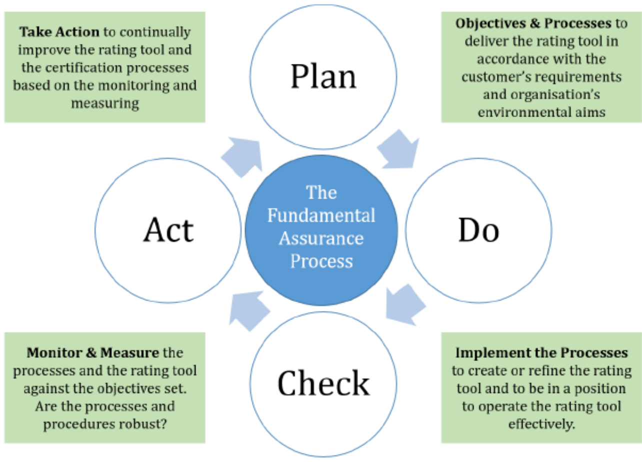


Figure 5-2: Plan-Do-Check- Act methodology
(After ISO9001, 2008)

The fourth stage is the action stage, where continuous action is taken to see whether it meets the client's expectations or whether sustainability is taking place in the buildings. If the tools are not meeting the expectations, they must be improved according to the challenges they face. (Khan et al., 2021).

5.4 The Tool Framework

The framework for the development of the tool was adopted from the comprehensive assessment system for sustainable urban development (CASSUD). Having considered literature on development of GBTs, the idea of integrating various strategies was advocated for. The consideration of environmental, economic, and social strategies was key to applying the theories seen in literature into a practical solution to achieving green low-cost houses. The CASSUD is a framework used in a study by Abu Bakar and Cheen (2013). This framework was adapted in the study because it outlines all the parameters necessary to achieve sustainability in its entirety. The criteria level recognized all significant built and unbuilt characteristics as well as their interrelationships with the environment. It comprises three major levels namely, the outcome, design measurement indicators, and sustainability criteria level (Abu Bakar and Cheen, 2013). The goal level describes the ultimate achievement of the tool. The environmental performance of urban areas of development or redevelopment through the framework, including buildings, is achieved.

The overall score of the sustainable urban development area is calculated by using the formula in equation 5-1 below:

$$CASSUD = \sum SCn\ X\ Wn \qquad \text{Equation 5-1}$$

Where CASSUD is the Comprehensive Assessment System for Sustainable Urban Development:
n is the numeric indicator for each sustainability criteria parameter:
SCn is the score of the Sustainability Criteria of each of the n indicators: and
Wn is the weightage attributed to the n indicator to each Sustainability Criteria.

The calculation of the final score of CASSUD on a particular project in equation 5-2 is as listed below:

$$CASSUD = \sum EnxWEn + ScxWSc + EcxWEc + BxWB + SxWS + CTxWCT \qquad \text{Equation 5-2}$$

Where En represents Environmental criteria:
Sc represents Society criteria:
Ec represents Economics criteria;
B represents Building Forms criteria;
S represents Site/Land uses criteria: and
CT represents Communication and Transportation criteria (Hassan et al., 2013).
CASSUD was appropriate to be considered because it had both the social and physical aspects of assessment for GBTs. This was in keeping with the study's goals, which included creating a tool for evaluating sustainable, low-cost housing. To adapt the framework consideration of building bylaws, local materials and strategies and expert knowledge from building industry specialists was considered. Environmental, social, and economical building form, site/land use, communication, transportation criteria, and unique indicators for each of the criteria were all part of the framework, as demonstrated in Figure 5.3.

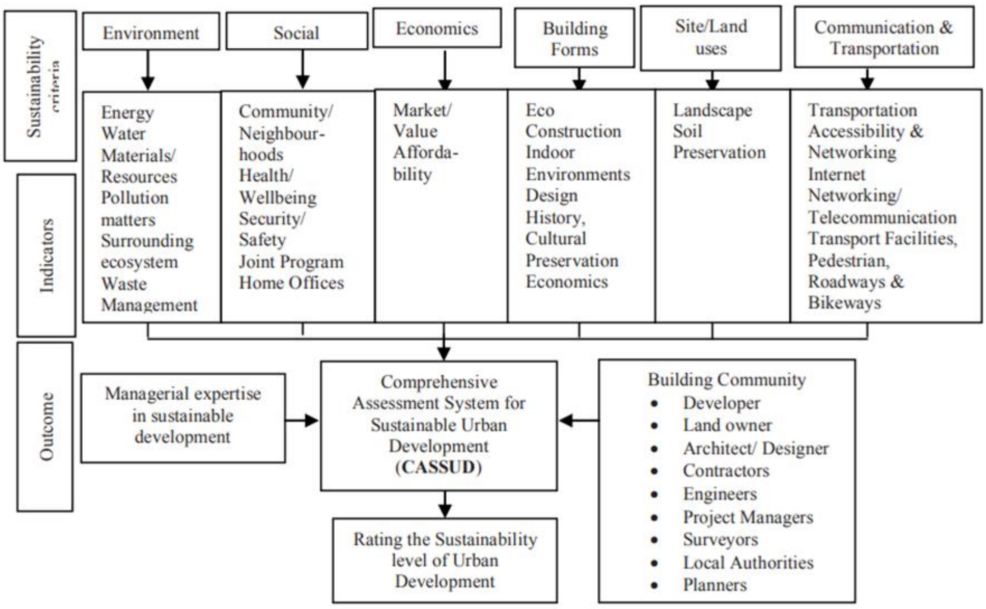


Figure 5-3: CASSUD conceptual framework
(After Abu Bakar and Cheen, 2013)

Figure 5.3 depicts the tool development process in detail. The design process, the adaptation of local building laws, adaptation of preferred criteria from GBTs, selection of local materials, and social and economic, and environmental considerations were part of the structure. The scoring in the tool was based on percentage of GB compliance as set by the tool structure.

5.5 Integration Analysis

Integration analysis brings together different concepts, philosophies, and tools to merge them into one concept. The ideas behind amalgamation are that it picks the best concepts to make a process answer a problem. In the study, it was viewed as a way of bringing various concepts, methods, and criteria of GB to achieve the goals of green sustainability (Rouse, et al., 2016; Wang and Zhang 2016)

The summary of all criteria is shown in Figure 5.4, areas that were identified under the environmental, economic, and social pillars include resource use, use of local materials, financial, empowerment, stakeholders, education, materials, standards, and criteria. Passive solar designs, photovoltaic panels, and solar heaters were among the energy criteria proposed. Other strategies were the use of biofuel and wind energy.

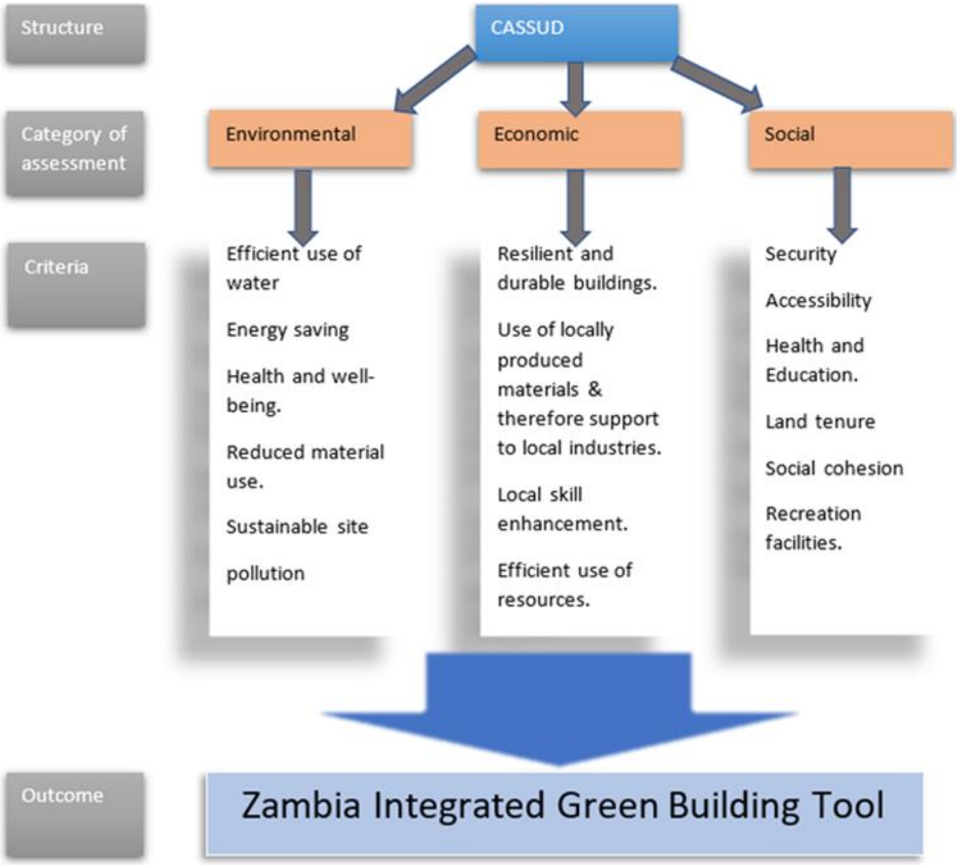


Figure 5-4: Summary of Tool development
Source: Author

5.6 Application of Theory to the Development of the Tool

Eight pillars make up the tool's basic framework: environmental, social, economic, educational, management, innovation, community participation and regional priority. Literature review and theme development were used to categorize the data. The information in various categories and criteria was derived from the selected questionnaire survey and interview results and selected GBRT websites. Evaluators were purposively selected from consultancy firms that had projects that had been either certified or had attributes of greenness. The number of evaluators was restricted to five due to Transparent Choice tool's limitations.

From the eight pillars different criteria were selected based on the results for the preferred criteria as seen from Table 5.1. For example, the environmental criteria were selected from LEED, BREEAM, Green Star, SBAT and SHG. The social criteria were taken from SBAT and SHG. The economic criteria were taken from SBAT, SHG and LEED. The educational criteria were taken from SBAT and SHG. The management criteria were taken from Green Star and LEED and DGNB. The innovative criteria were taken from LEED tool, community participation from SBAT and SHG, Regional priority from LEED and security and safety from SBAT. LEED tool was used to adapt ecological categories, while the BREAM and SBAT tools were used to adapt the environmental and social and economic sustainability. Whole-building design was adapted from Green Star, while education and impact on the local economy were adapted from SBAT and SHG.

There are 17 criteria from which users can choose assessment parameters. Energy has nine sub-criteria, with energy requirements, energy reduction, and monitoring tools as the key factors. Calculation of the solar energy needs has been embedded in the tool. Once the building area is inputted, the results show all the solar utilities necessary for that specific building. The health and well-being criterion includes 14 sub-criteria: visual comfort, passive ventilation, natural lighting through daylighting calculations, control of light, air, and noise pollution, and identification of hazardous materials.

Within the region, 14 different locally produced building materials were identified. These materials had low embodied energy, good heat transmitters, and high reflectivity (R-value). The sustainable site has 20 parameters that include green and brownfield use, distance from public transport, emissions reduction, landscaping designs, sustenance of habitats, heat island reduction, surface water runoff, and biodiversity programs. Nine standards were identified to reduce pollution and waste, refrigerant gases emissions, control of construction waste, reduced loss of landfill and recycling of waste. The transport gauge has 10 sub-criteria, that help reduce congestion and ease the movement of pedestrians and cyclists around housing development.

The economic category includes job creation, locally created items, and local labour, while the social category comprises recreation and social cohesiveness. The GB knowledge contains information on sustainable strategies for tenants and developers, whereas the management comprises building management and maintenance after construction. Innovation promotes the development of long-term concepts that do not fit into any other category. The water performance options included rainwater for gardening and external use and stormwater capture. Hydra form blocks, sisal, clay, and bamboo would be used for the construction envelope, while the roofing would be made of clay tiles, iron sheets, and thatch. Large apertures and window overhangs to achieve daylighting were included. Sustainable sites included landscaping, green open areas, community spaces, pathways, and bicycle tracks. By lowering the use of CFCs, lead paints, and lead, copper, and iron pipes in construction, toxic waste will be reduced.

Table 5-1: The application of tool criteria and SDGs into the ZIGBAT

Categories	**LEED, BREEAM, Green Star**	**SBAT**	**SHG**	**SDGs**	**Application to ZIGBAT**
Methodology	Use of design guidelines Innovative practices Standards and technologies Development of categories for assessment	Performance of a building in economic, social, and environmental criteria Occupant’s comfort and inclusive environment	Responsive and Sustainability Integration Processes	creating career and business opportunities, safe and affordable housing, and building resilient societies and economies	Development of categories for assessment Six categories: environmental, social, economic, education, management, and innovation
Environmental criteria	Energy and atmosphere Health and wellbeing Water efficiency Material and resources Sustainable sites Transport	Local economy Adaptability Access to facilities Education, health, and safety	Waste management Biodiversity	Air quality Waste management	Energy use Health and wellbeing Water efficiency Material and resources Sustainable sites Transport Waste management

Table 5-2: The application of tool criteria and SDGs into the ZIGBAT (Cont.)

Categories	**LEED, BREEAM, Green Star**	**SBAT**	**SHG**	**SDGs**	**Application to ZIGBAT**
Application					
	energy metering and energy-efficient equipment (reduction of greenhouse gases energy-efficient transport system low carbon design photovoltaic systems Renewable Energy Daylighting Rainwater harvesting	Good daylight from window and skylights Lighting Comfort through monitoring light levels/ LED lights control their thermal environment natural and passive ventilation Easily monitored localized metering system for water and energy carparking, paths, roads and roofs that have absorbent/semi absorbent/permeable surfaces reuse Greywater from washing/relatively clean planting on site with low / appropriate water requirements Encourage public transport, walking and cycling	Detecting household energy consumption solar energy, photovoltaic panels Solar heaters Use of biogas for energy Use of local materials (stabilized blocks, bricks, bamboo, mud brick) Control noise levels by sound absorbent building materials Natural cooling and heating/ cross ventilation semi open spaces/ verandahs/ Rainwater harvesting/ wastewater recycling/ Public transport available	utilizing local materials Improve air quality and municipal and other waste management eliminating dumping, and increasing recycling and safe reuse	Detecting household energy consumption Use of local materials with low carbon footprint Recycling and reuse of water photovoltaic systems Renewable Energy Daylighting Rainwater harvesting reuse Greywater planting on site with low / appropriate water requirements Encourage public transport, walking and cycling Use of rainwater harvesting and greywater reuse Natural cooling and heating/ cross ventilation semi open spaces/ verandahs/

Table 5-3: The application of tool criteria and SDGs into the ZIGBAT (Cont.)

Categories	**LEED, BREEAM, Green Star**	**SBAT**	**SHG**	**SDGs**	**Application to ZIGBAT**
Social criteria		Occupant's comfort Inclusive environment Access to facilities Education/ health and safety	Access Health Education Inclusion of diversity in population Social cohesion	Green spaces Resilient buildings Transport system	Access to facilities Education/ health and safety Social cohesion Green spaces Resilient buildings
Application					
		Building (s) within 400m of disabled accessible and affordable public transport Occupied spaces that are accessible to ambulant disabled / wheelchair users Space with fully accessible toilets within 50m along easily accessible route		safe, affordable, accessible, and sustainable transport safeguard cultural and natural heritage safe, inclusive, and accessible, green, and public spaces, for women and children, older	Building (s) within 400m of disabled accessible and affordable public transport Occupied spaces that are accessible to ambulant disabled / wheelchair users safe, inclusive, and accessible, green, and public spaces, in

Table 5-4: The application of tool criteria and SDGs into the ZIGBAT (Cont.)

Categories	LEED, BREEAM, Green Star	SBAT	SHG	SDGs	Application to ZIGBAT
Economic criteria		Capital costs. Ongoing costs Adaptability and flexibility Efficiency of use	Local building production, Diversification in housing use to create wealth Promotes local experts and tradesmen in GB Education of tenants in maintenance of GB Training of experts/ tradesmen to green bld.	equal rights to economic resources basic services, new technology and financial services, including microfinance financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Local building production, Diversification in housing use to create wealth Promotes local experts and tradesmen in GB Education of tenants in maintenance of GB Training of experts/ tradesmen to green bld.
Education		Space/facilities available for education (seminar rooms / reading / libraries) per occupied space Construction training provided on site. Users who can access information on health & safety issues (i.e., HIV/AIDS), training and employment opportunities easily (posters/personnel/intranet	Local community engagement in assessment Local skill in development of sustainable materials	government provision of financial and technical assistance for GBTs	Local community engagement in assessment Local skill in development of sustainable materials

Table 5-5: The application of tool criteria and SDGs into the ZIGBAT (Cont.)

Categories	LEED, BREEAM, Green Star	SBAT	SHG	SDGs	Application to ZIGBAT
Community participation		Users actively involved in the design process / Active and representative management user group All new users receive induction training on building systems Detailed building user manual Local economy	Provision of systems information to tenants on ongoing monitoring energy, water and internal air, humidity, and wind levels in buildings		a) Provision of systems information to tenants on ongoing monitoring energy, water and internal air, humidity, and wind levels in buildings
Management			Control of use of material Occupants of buildings are introduced to occupation building manuals and green building maintenance		Occupants of buildings are introduced to occupation building manuals and green building maintenance
Innovations	Innovation credits provide the opportunity to achieve credit for exceptional performance above the requirements set by LEED		Creativity and pioneering application of new ideas in facilities management New designs and materials, local economies		New designs and materials locally produced and that promote local economies

Table 5-6: The application of tool criteria and SDGs into the ZIGBAT (Cont.)

Categories	**LEED, BREEAM, Green Star**	**SBAT**	**SHG**	**SDGs**	**Application to ZIGBAT**
Regional priority	Geographically specific environmental, social equity and public health priorities (under LEED)	Capital cost allocated to address employment, training etc.) during construction process Tender / construction involving local contract./manufacturers Capital cost not more than fifteen % above national average building costs Existing Buildings or more of capital costs allocated to new sustainable/indigenous technology		Promotion of local rating tools	Tender / construction packaged to ensure involvement of small local contractors/manufact. d) Existing Buildings or more of capital costs allocated to new sustainable/indigenous technology

5.7 Adaptation of the 11th Sustainable Development Goal

Some parameters of the tool were adopted from the 11th SDG, particularly those in line with the study's findings shown in Table 5.2. as applied from 11th SDG provision of access to safe, affordable, accessible, and sustainable transport systems. It was interpreted by creating transport nodes to enable an efficient transport system. Separate sidewalks, cycling lanes, bicycle storage, and ample parking lots were provided as solutions in the Tool. The disabled people are catered for as well and reducing the proportion of untreated wastewater and increasing recycling and safe reuse. This could be achieved by the provision of solid waste outlets within the buildings and on-site water treatment.

Table 5-7: Application of the 11th SDG in GBTs

Items	Description of the Goal	Application
1	Provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport with special attention to the needs of those in vulnerable situations women, children, persons with disabilities and older persons.	Having transport system near housing development Special features on transport system for the disabled Separate walkways and cycling tracks, bicycle storage and parking
2	By 2030, all countries will enhance inclusive and sustainable urbanization and capacity for participatory, integrated, and sustainable human settlement planning and management.	Inclusion of all parties in the buildings sector from design up to the completion of projects Inclusion of clients to maintain buildings after handover through GB. sustainable manuals Training professionals in GBTs
3	By 2030, reduce cities' adverse per capita environmental impact by paying special attention to air quality and municipal and other waste management.	Allow for good air quality through cross ventilation. Use landscaping to reduce on-site dust and pollutants Reduce on municipal waste through on-site waste segregation and recycling
4	By 2030, provide universal access to safe, inclusive, and accessible green and public spaces, for women and children, older persons, and persons with disabilities.	Provision of open spaces in housing designs Provision of public spaces like play parks, swimming pools, Well lite walkways and cycling tracks
5	Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.	Support community development of local materials Support community projects
6	Improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and increasing recycling and safe reuse globally.	Recycling and site water treatment plans Use of gray and rainwater harvesting

5.8 Application of CASSUD in the Tool

Integration of methods and systems enabled the development of a tool that answered many of the participant's concerns. The variables to achieve sustainability were adapted into ZIGBAT from CASSUD (Abu Bakar and Cheen, 2013). Other parameters from the study were also included in the framework to create an integrated system. A new formula for calculating sustainability in buildings was also adapted from CASSUD as follows:

ZGBAM = ∑SCn X Wn

ZGBAM = ∑EnxWEn + ScxWSc + EcxWEc + EdxWEd + MgxWMg + IxWI

For the tool, the components were broken down as listed below:

The n values ranged from 1 to 5 weights. The ∑SCn were taken from estimates in several GBTs, and the total green building compliance was 100 percent.

En=10%, Sc=5%, Ec =3%, Ed= 3%, Mg=7%, I= 2%

ZGBAM = ∑En xWEn + Sc xWSc + Ec xWEc + Ed xWEd + Mg xWMg + I xWI

= (0.1 x 5 + 0.05 x 3 +0.03 x 3+ 0.03 x 3 +0.07 x 2 + 0.02 x 2) x100

= 100%

When measuring the green building compliance against the set criteria, the aim is to meet all the above parameters. If the measurement is below the 100 percent mark, then improvements can be made to reach the target through the building design or construction process.

5.8.1 Technical specification for Zambia integrated green building assessment tool

The tool is computer-based and was developed with PHP (2015) programming language using NET Framework 4.0 and MySQL 5 as the database engine. HTML, Bootstrap, JavaScript, and Jquery are used on the front end, and web browsers such as Microsoft Internet Explorer, Mozilla, Google Chrome, or later -MySQL Server are operated on the backend. Any of the following operating systems could be used: Windows XP, Windows 7, Windows Vista, Windows 10, and MacOS. Because the tool is web-based, it can be accessed from any browser, including mobile devices.

Users choose their preferred parameters by clicking the assessment icon. If all the requirements are met, the program will yield 100 percent compliance. If one of the mandatory criteria is not selected, then the tool will not proceed until that is done. The outcomes are both descriptive and quantitative in nature. An evaluation report directs the development process and identifies areas that need to be improved to achieve the highest possible score. The program necessitates the computation of the structure's area and the site's latitude. Building components were divided into floors, walls, roofs, finishes, and fixtures as shown in the flow chart in Figure 5.5.

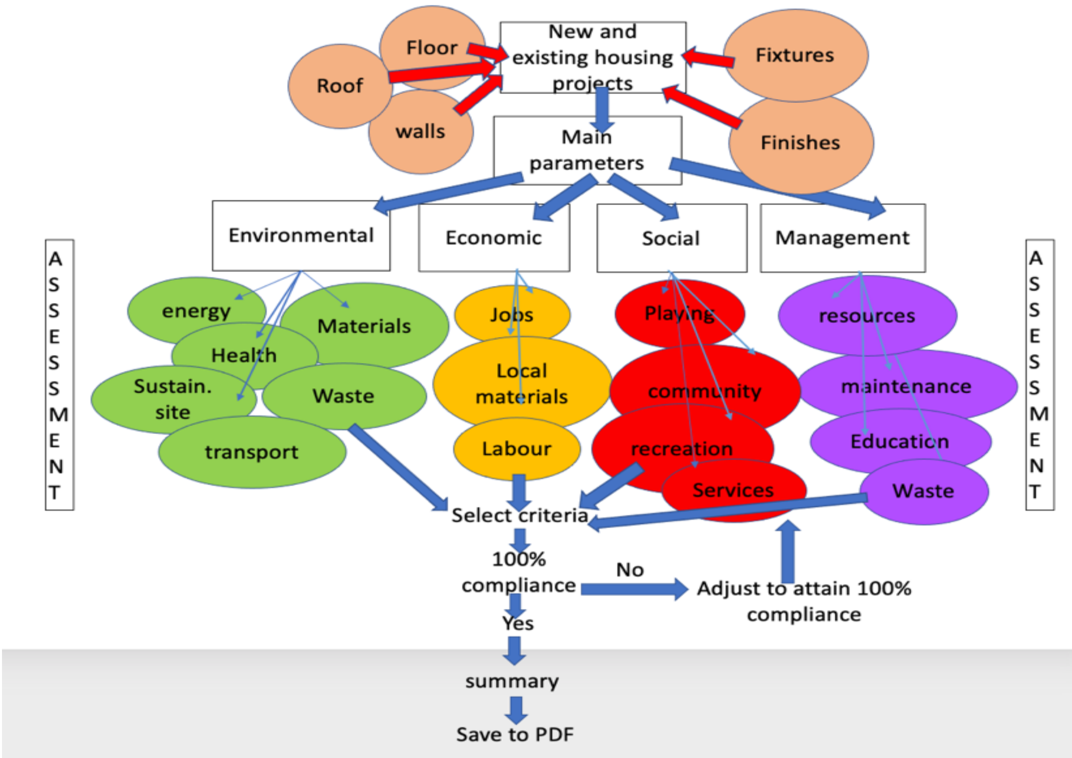


Figure 5-5: Flow chart of ZIGBAT
Source: author

Upon selection of all the criteria, a report is generated showing the percentage of green compliance. The user can reset their parameters and a new report will be generated automatically. The tool underwent an evaluation to see whether it worked according to the goal and several appraisals were undertaken. The integration of concepts from GB frameworks and rating tools culminated in a new tool that was called Zambia Integrated Green Building Assessment Tool (ZIGBAT). It integrated processes in three stages:

a) Framework;

b) Criteria development; and

c) Assessment.

The development of criteria was based on literature comparisons, questionnaire survey results, and interview outcomes. Verification by 5 experts and using the ISO 9001 guidelines defined the tool's execution mechanism. The verification process was driven by established objectives, and the purpose of the evaluation was determined by the goals set (ISO, 2015). A thorough check and measurement of the tool's performance was carried out to meet international best practices of GB assessment.

Units for scaling criteria in ZIGBAT

The units of the criteria vary, they are both qualitative and quantitative in nature. The outputs are either in units or note form. For example, energy is given as kwh, the wall reflectance value (R-value) is km2/w, and the amount of lighting entering the building is calculated in lux. Rain-water harvesting is measured in litres. However, most of the quantities are expressed as a percentage, for example, the absorbance value of the roof and the glazing area. All the measurements are incorporated into the program so that once the building's dimensions are inputted, the correct output is given.

5.8.2 The strength of the tool

According to Kaatz et al. (2005), rating tools should be built with integration, transparency, and availability in mind, as they will result in an effective and content-relevant assessment. The strength of the tool is that it was built around four primary principles: accessibility, correctness, maintainability, and usability. The tool is available via the internet and can be viewed in any browser or operating system. The tool's accuracy is shown by combining several highly ranked criteria that have been evaluated and run in prior GBTs. The concept is flexible enough to adapt to changing consumer needs, and it offers a user-friendly interface for experts, clients, and developers to use. The first interface in the tool allows the operator to input the area of the building and the latitude. Once the information is assigned, a new window displays 9 environmental criteria, as shown in Figure 5.6

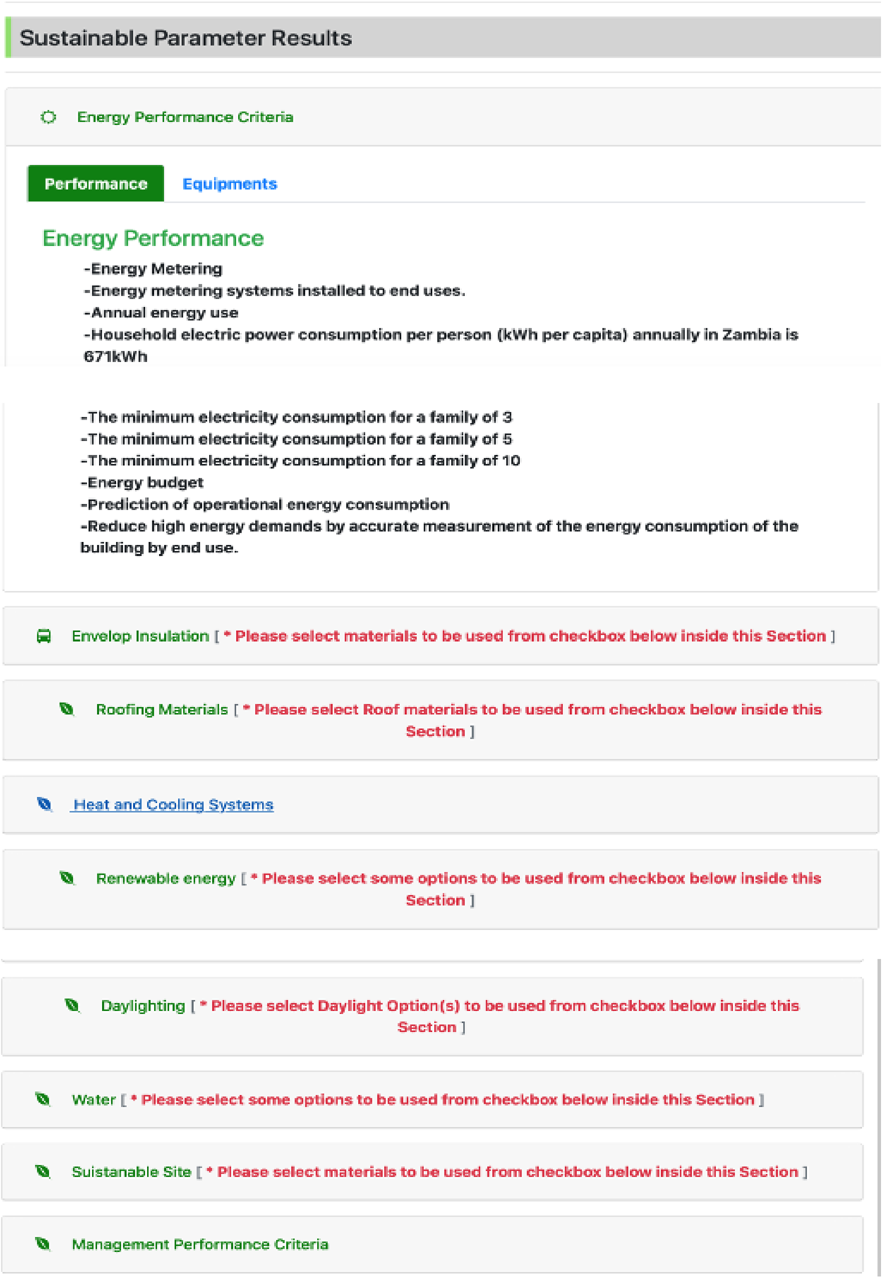


Figure 5-6: Assessment criteria in ZIGBAT

Source: Author

The tool allows for both partial and complete evaluation. The incomplete evaluation output lists recommended criteria in each category, but the full assessment displays both the required parameters and the percentage of green building compliance to be achieved. Energy, envelop insulation, roof materials, heat and cooling systems, renewable energy, daylighting, water, sustainable site, and management performance are among the main icons on display. Sub-criteria can be accessed for each primary parameter, and desired information can be selected. The user is expected to choose the minimum requirements for green compliance.

5.8.3 Energy and envelop insulation

When the energy criterion is opened, it displays the minimum performance of a structure and equipment, such as solar panels, lighting types, and power metering. Enveloped insulations are materials that cover the frame of a building, and these are shown in Figure 5.7. Different materials' padding and conductivity characteristics were considered, such as walling, flooring, and ceiling supplies. For example, the use of stabilized blocks, bamboo, brick, and recycled materials.

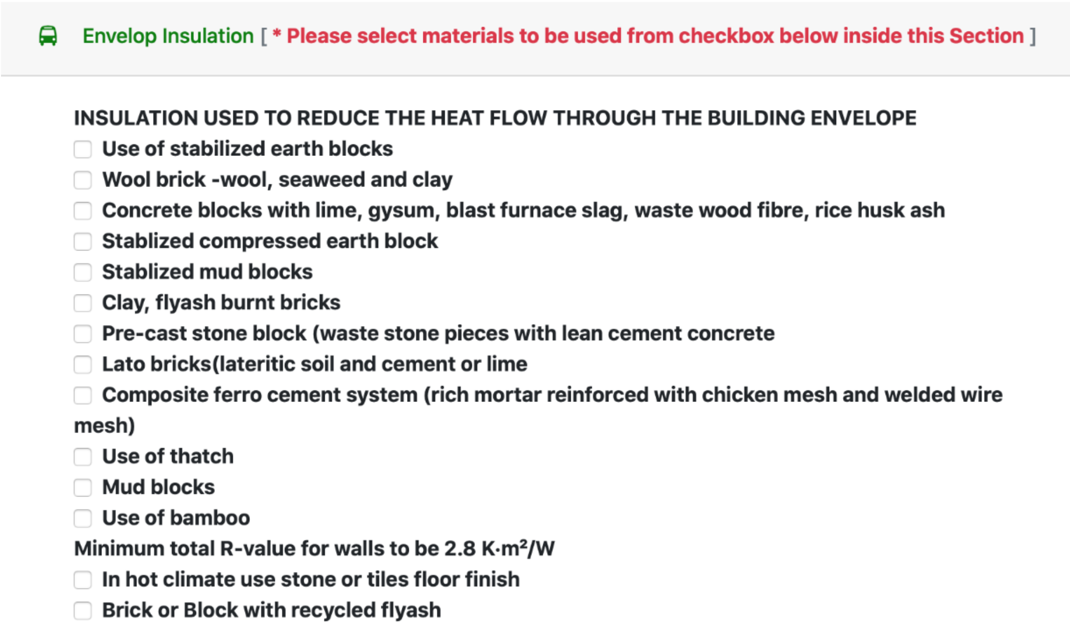


Figure 5-7: Criteria for enveloping insulation
Source: Author

5.8.4 Roofing materials

The Tool allows the user to choose roofing resources that limit heat loss or heat gain in buildings, as illustrated in Figure 5.8. It provides absorbency values for various roofing structures and the option of using materials that are widely available in the region and are low-cost. The roofing materials are simple to manufacture, energy-efficient, and recyclable.

Roofing Materials [* Please select Roof materials to be used from checkbox below inside this Section]

Roof absorbency rate non porous roofing sheets 0.1-0.5 %
Minimum total R-value (for a roof with a solar absorbance of more than 0.55) to be 4.1 K·m²/W
Absorbency values:
Off White 0.35, Light Cream 0.30

- [ ] In areas where there is clay use clay tiles
- [ ] In areas where there is bamboo use bamboo as roofing members
- [ ] Thatch
- [ ] Clay tile roof
- [ ] Gypsum sisal conoid
- [ ] Bamnboo and wood shingles
- [ ] Corrugated fibre concrete sheets

Figure 5-8: Roofing material criteria
Source: Author

5.8.5 Heating and cooling systems

Heating and cooling systems are those that help to control internal temperatures in buildings for comfort. Consideration is given to natural means of controlling heat in buildings, as demonstrated in Figure 5.9. For example, the use of cross ventilation, solar heating, and biomass for warming buildings.

-Increased cross ventilation, thermal mass and ceiling fans should be used rather than air conditioning
-Solar direct or indirect gain systems can be used for heating
- Biomass heating be used for heating and cooking
- Passive environmental control System
- Cross ventilation
- Openings on two sides of a space
- Breeze paths are directly across a building or space and pass through the openings on opposite windows
- The area of glazing within a façade not exceed 30%.
- Glazing should be limited on east and west facades to avoid unwanted heat gains

Figure 5-9: Heat and cooling systems criteria
Source: Author

5.8.6 Renewable energy and daylighting

Renewable energy and daylighting incorporate the use of solar, wind, and bioenergy with their supporting equipment. The Tool gives a final assessment based on the required daylighting, the size of openings required and the type of paint colours on the walls, floors, and ceiling. The parameters are shown in Figure 5:10.

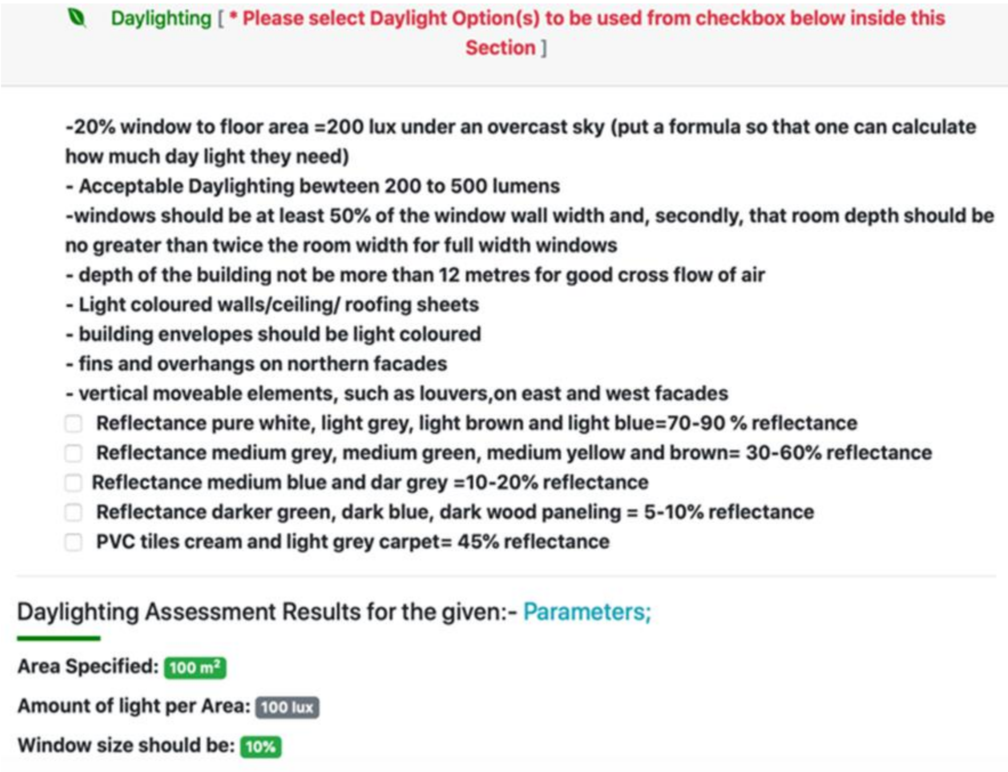


Figure 5-10: Renewable energy and daylighting
Source: Author

5.8.7 Water management

Water management is a metric for ensuring that the resource is used efficiently. It outlines all the standards for using and conserving the commodity. Recycled water, rainwater harvesting, and run-off water reduction are only a few solutions outlined in Figure 5.11. The tool calculates how much rainwater is gathered for a given square area of a structure.

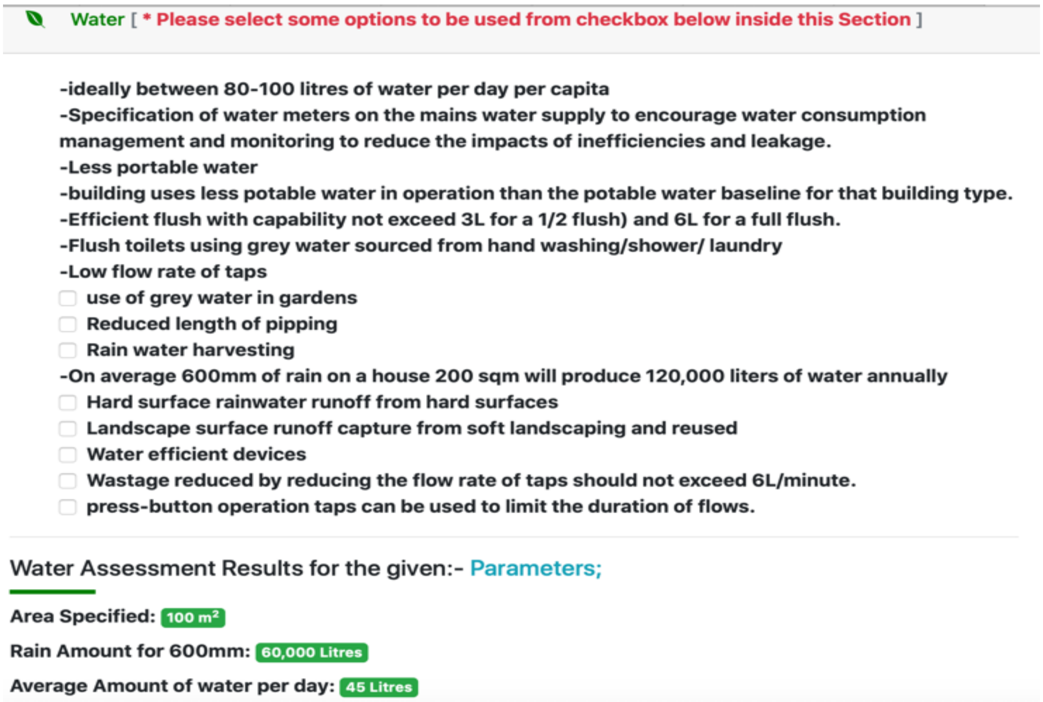


Figure 5-11: Water management criteria

Source: Author

5.8.8 Sustainable site

The sustainable site criterion outlines how to construct and maintain a green site. Specification of the site's distance from the nearest public transportation system and how to deal with the maintenance of both brown and greenfield have been demonstrated. It further explains protecting habitats from noise, air, and light pollution (see Figure 5.12). Green building compliance in this category is estimated as a percentage.

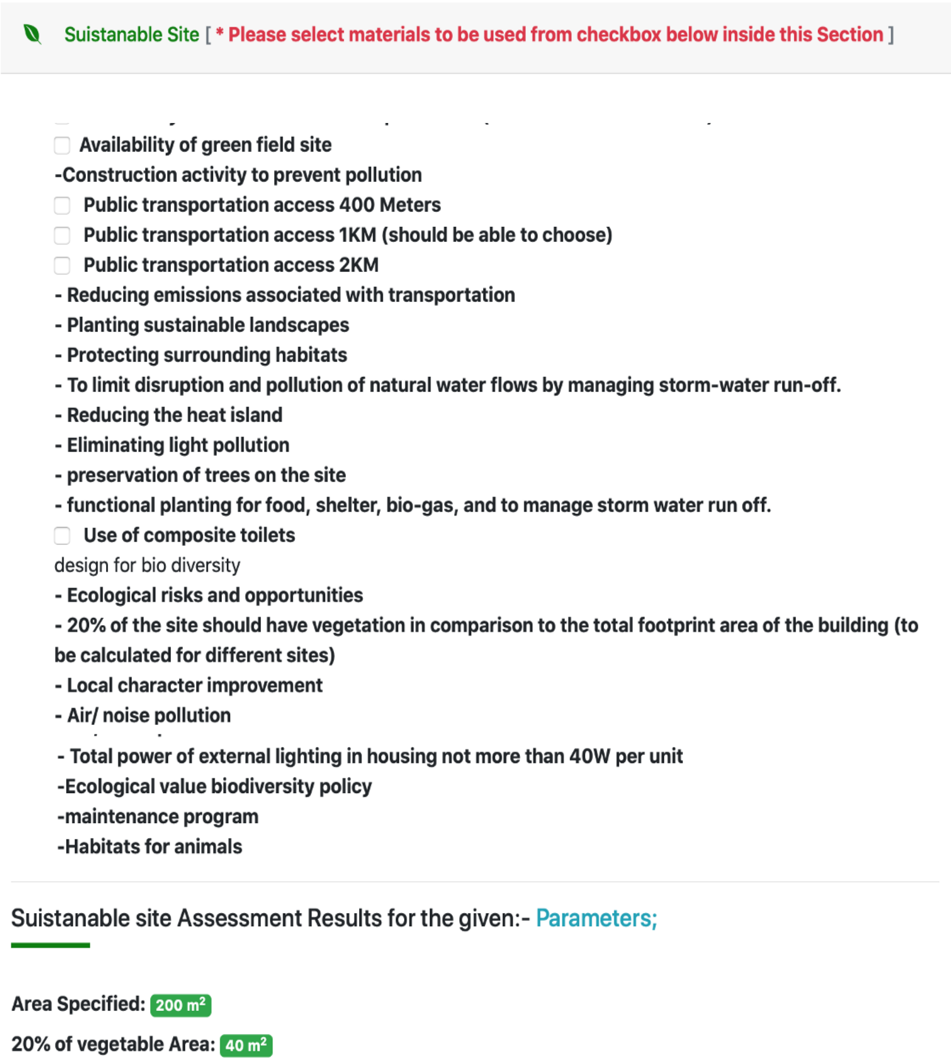


Figure 5-12: Sustainable site criteria
Source: Author

5.8.9 Management performance

The management performance criterion gauges environmental, social-economic organization strategies to achieve green compliance, as presented in Figure 5.13. Systems for good waste management, sustainable construction materials, health and well-being, transportation, pollution, economics, education, social cohesion, and innovation are promoted. Project administration is enhanced through life cycle analysis, where life cycle costs are monitored from design, construction to the demolition of buildings. Tenants are given access to occupation guidelines to maintain their structures. The criteria also include selecting low-embodied-energy building materials with a traceable life cycle cost.

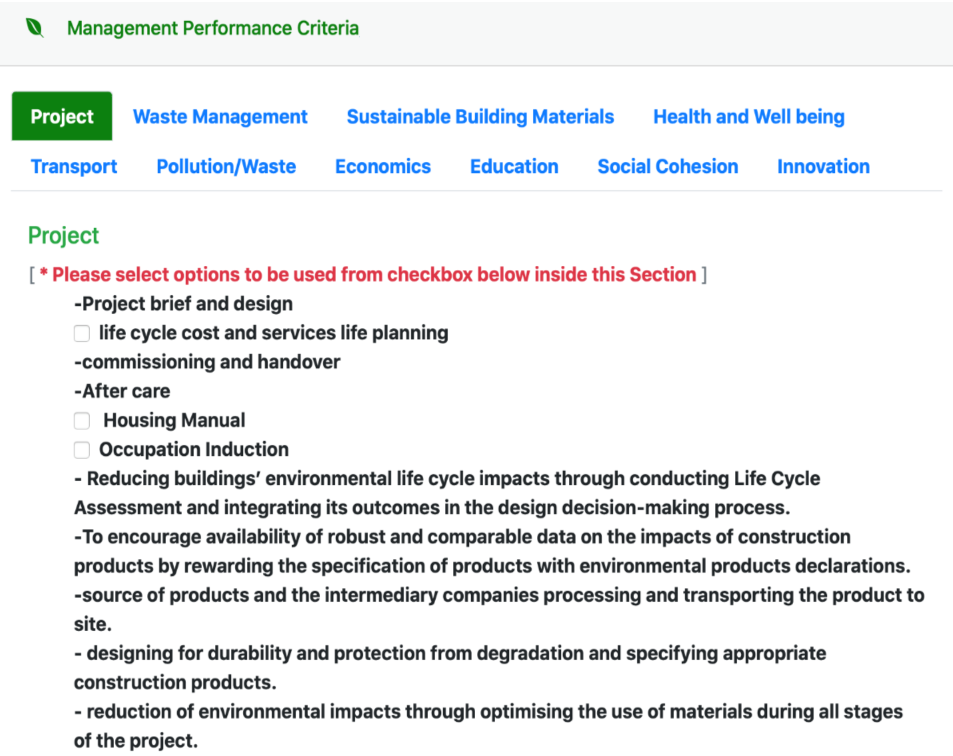


Figure 5-13: Management performance criteria
Source: Author

5.8.10 Waste management

The waste management parameter falls under general organization and demonstrates the reduction of garbage before it reaches landfills. The criterion promotes the use of recycled materials and provides waste-reduction measures.

5.8.11 Sustainable building materials

Sustainable building materials are manufactured, packaged, and delivered with a low carbon footprint. They have a low life cycle cost and include recycled, non-hazardous, and low embodied energy. The selected materials were locally produced and easy to operate, based on the results of the survey and interviews.

5.8.12 Health and well-being

Health and well-being describe the required internal environment, the type of finishes, fixtures, and avoidance of hazardous materials in buildings. The aim is to promote a safe and healthy environment. It includes good visual comfort, use of passive ventilation and utilization of daylight. As shown in Figure 5.14, good acoustic performance can be achieved through sound reflective and absorbent materials. The Tool differs from other tools in that it emphasizes the utilization of natural air movement rather than artificial ventilation.

Health and Well being

- Visual comfort
- good practice daylight factors, reduced glare and having an adequate view out.
-Indoor quality
-Managing harmful emissions from construction products with the appropriate standards. – quality.
-Specifying an appropriate ventilation strategy that maintains good indoor air
-Thermal comfort
-Processes to monitor and measure the levels of fresh air in regulary occupied space and maintain carbon dioxide concentrations at best practice levels.
- Security
-Safe and health surroundings
- best practice acoustic performance levels appropriate to the functional activities in occupied spaces.
- monitoring of noise from building systems and exterior sources, and the maintenance of such at appropriate levels.
-green outdoor space
- reduce the health risks to building occupants from the hazardous materials usch us asbestos, lead and polychlorinated biphenyls

Figure 5-14: Health and wellbeing criteria
Source: Author

5.8.13 Transport

A good transportation system minimizes the number of people who drive their cars, lowering carbon emissions in the environment. Figure 5.15 shows a strategy that directs the user to employ alternative modes of transportation by developing homes near job areas, schools, and services structures.

Transport

[* Please select options to be used from checkbox below inside this Section]

Encourage the use of alternative transportation modes such as public transport, walking or cycling.

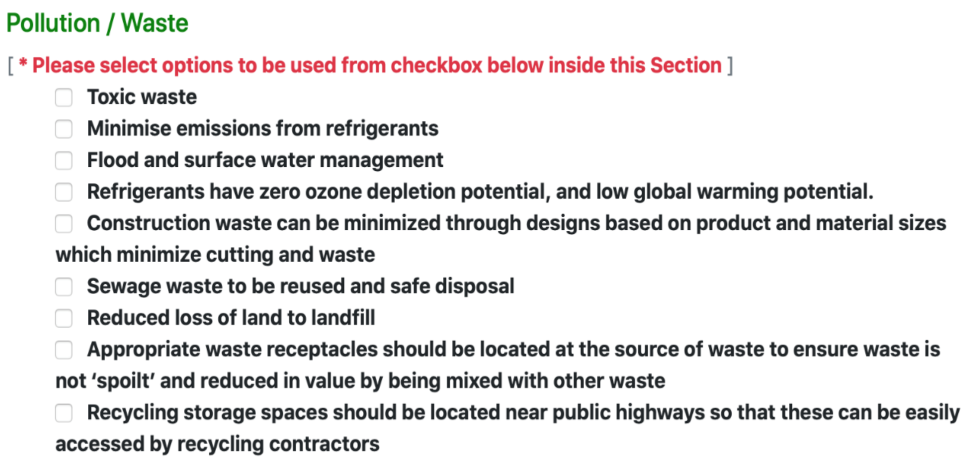
- [ ] Building is located 100, or less metres to disabled accessible public transport
- [ ] Compact development
- [ ] Access to facilities
- [ ] Locating housing near employment, education, health and recreation facilities, shops, banking, post offices and telecommunications, business and government services enables households to access this by walking, or cycling, avoiding the need for cars.
- [ ] Proximity to amenities
- [ ] Housing should be located near good public transport nodes, including bus, train and bus rapid transport systems (BRT). Walking distances between public transport nodes and housing should be not be over 2 km and ideally should be less than 400 m.
- [ ] Pedestrian and cycling routes
- [ ] Provision for cycling, safe parking areas and safe routes encourage cycling as an alternative to the use of motorised vehicles
- [ ] Safe movement in buildings

Figure 5-15: Transport criteria
Source: Author

Pedestrian walkways, cycling paths, and secure bicycle parking areas are among the infrastructure components. It also entails the establishment of safe paths around the structures.

5.8.14 Pollution and waste

Reduction in pollution and waste are key elements in achieving sustainable housing development. The criterion allows the user to select elements they would consider important to reduce pollution and manage waste. Reduction in emissions, household recycling and waste segregation, construction waste management, reuse of sewage, and landfill waste reduction is illustrated in Figure 5.16.



Pollution / Waste

[* Please select options to be used from checkbox below inside this Section]

- ☐ Toxic waste
- ☐ Minimise emissions from refrigerants
- ☐ Flood and surface water management
- ☐ Refrigerants have zero ozone depletion potential, and low global warming potential.
- ☐ Construction waste can be minimized through designs based on product and material sizes which minimize cutting and waste
- ☐ Sewage waste to be reused and safe disposal
- ☐ Reduced loss of land to landfill
- ☐ Appropriate waste receptacles should be located at the source of waste to ensure waste is not 'spoilt' and reduced in value by being mixed with other waste
- ☐ Recycling storage spaces should be located near public highways so that these can be easily accessed by recycling contractors

Figure 5-16 Pollution and waste management
Source: Author

5.8.15 Economic sustainability

The integration of environmental and economic sustainability was key to the development of the Tool. This criterion allows users to choose activities that will have a long-term positive impact on local economies. Local building material production was considered and diversification of financial activities to enable housing tenants to generate income through the housing projects. It encourages local specialists and tradespeople to participate in the creation of houses and related infrastructure.

5.8.16 Education criterion

Education is incorporated into the design of green constructions under this criterion. At the start and end of the project, all stakeholders (tenants, developers, and specialists) are given information about green building implementation and maintenance. Repair guides, tradesmen skills training, access to green building supplies, and sustainability information keep residents informed.

5.8.17 Social cohesion

Tenants with social cohesiveness can interact with their neighbours and the environment for the common good. It facilitates physical, physiological, and mental development. The criterion describes how inhabitants will connect with their community and how recreational areas would encourage interaction. All stakeholders are involved in meeting this criterion, from the design to the occupation phase.

5.8.18 Innovation

The innovation criterion was adapted from the BREEAM tool and integrated features from other tools like SBAT. It demonstrates ideas that do not fall into the mainstream of environmental, and social-economic, sustainability. Tenants, developers, and professionals participate in new designs and materials that are locally developed and boost local economies to foster innovation.

5.9 Scope of the Tool

The Tool is meant to help designers, planners, developers, and tenants achieve green low-cost housing by selecting design and construction practices that enhance green building compliance. Different housing projects can be compared for green compliance through the tool. The percentage of conformity with the tool's standards is used to calculate the assessment's results. Although it can be used in conjunction with other GBTs, the Tool's parameters lack the scales and rates seen in other tools.

5.10 Validation

Validation is assessing the degree to which an instrument accurately gauges what it is supposed to measure (Middleton, 2022). Tool validation is usually defined to mean *"substantiation that a computerized framework within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the Tool"* (Schlesinger et al. 1979, p.103). A framework should be validated to show that the results produced from the Tool can be compared with real-time results. A framework cannot be tested for its validity in all its domains as Sargent (2010, p.166) stated that, "It is often too costly and time-consuming to determine that a framework is valid over the complete domain of its intended applicability." Instead, tests and evaluations are conducted until sufficient confidence is obtained that a framework can be considered valid for its intended application (WGC, 2015). The validation process of the framework was conducted through expert opinion. The experts were involved in selecting the criteria, and they tested the tool and validated it. The Tool for GB assessment could be validated by following the ISO 9001 standard tool development as well. The other validation method is through simulation frameworks that demonstrate the actual assessment virtually. There could also be face Validity where Individuals knowledgeable about the system are asked whether the Tool and/or its behaviour are reasonable.

5.10.1 Validation of the tool

The Tool validation followed the ISO 9001 quality assurance system, which looks at the Plan-Do-Check-Act. The Tool's parameters were adapted based on the findings of the survey and interviews. The results were triangulated using AHP, which further validated the imputed data in the Tool. Five specialists examined the tool to see if it fulfilled their expectations, and if any input or ideas were considered.

According to Towell et. al. (2013), additional parts of the tool creation process, such as rating tool resources, development guidelines, method statements, and technical documentation, must be in place concurrently with the criteria development. The information's sources were valid because they were acquired from the GBTs ' websites, making it a trustworthy source. To increase the comprehensiveness and decrease biases, data was integrated from the various GBTs. Incorporating AHP into the technique and criterion selection process served as validation, as the respondents authenticated the final process and parameters. The indicators were reliable and accurate because they were tested against other assessment tools from which this Tool was developed.

5.11 Limitations of the Tool

The Tool had limitations in planning and assessing low-cost green houses, as points for certification were not generated. Some of the included parameters could not be scaled, thus only descriptive results could be produced. Not all the building materials and procedures used in the tool were commercially accessible, but they were thought to be appropriate for the industry. Detailed assimilation programs like lighting designs and air flow charts were missing in the tool, thus, demonstration of the concepts was not available.

5.12 Summary

The development of ZIGBAT was discussed in Chapter Five. It is made up of 8 components: environmental; social; economic; educational; management; and innovation. Integration of CASSUD, the 11th SDG, SHG, and results from the questionnaire survey make up the framework of the Tool. It was established as a planning tool to achieve green low-cost housing and includes 10 assessment criteria. Preference ranking in the AHP tool was used to rank the different methods and criteria. Expert feedback was used to validate the tool.

Chapter Six discusses the results of the questionnaire survey, interviews, literature review, and AHP ranking. Factors that could influence GBTs, knowledge and use in Zambia are addressed throughout the discourse. The methods and criteria for assessing GBTs were evaluated and key parameters in the tool were identified. Factors associated with the use GBTs were compared across the region. To make conclusions from the research, the findings of this study were compared to those of other investigations.

CHAPTER 6 DISCUSSION OF FINDINGS

6.1 Overview

Chapter Five presented the creation of the ZIGBAT, for planning and assessing low-cost housing in developing countries, with Zambia as the case study. It operates as an online assessment tool where the user inputs data and the system calculate the parameters required. For example, it can provide the required number of photovoltaic panels for an area of a building. It has 8 assessment categories selected from questionnaire survey, interviews, and selected GBTs.

The primary aim of this study was to investigate the knowledge about GBTs and the use of green building strategies and what criteria was preferred for use to develop a tool for assessing green low-cost houses in Zambia. The first question was to establish the knowledge about GBTs among the respondents and to what extent they were applied. Secondly, to explore the experiences in the use of tools in low-cost housing development. Thirdly was to assess the factors associated with the development of green low-cost housing. Fourthly the study sought to explore which environmental, economic, and social criteria were preferred to develop green low-cost housing and fifthly to develop a tool that could assess and plan green low-cost housing in Zambia.

This chapter is thus organized into four sections. Section one (1) shows the knowledge and the use of GBTs among the respondents and how this relates to the experiences in other countries. The factors associated with the use of GBTs are discussed in section two (2). The criteria necessary for achieving green low-cost houses is discussed in section three (3) and finally the development of an assessment tool for Zambia's low-cost houses is explained in line with all the literature outlined in the study.

6.2 Knowledge and Utilization of Green Building Tools

Knowledge on CGB was high while specific concepts in GBTs was low among the respondents and application of the strategies was also low. Awareness of the tools was high because 50 percent of the respondents have heard about the tools and 35 percent had read about them. The percentage of architects that utilized GBTs was higher than all the other professions (engineers, quantity surveyors, planners, and developers), and the significance in correlation between profession and utilization of GBTs supported this finding.

There is an association between those who were exposed to tools and an increase in knowledge, for example architects were more knowledgeable than the other professionals. This is also true for studies such as (Oke et al., 2019; William and Dair 2016; and Wu 2019) where they show differences in knowledge about GB based on the respondents in their studies. The null hypothesis that there was no difference in knowledge about GBTs among the respondents was retained for the CGB while for the knowledge of specific GBTs it was rejected as the architects had more knowledge. Architects had more opportunities to use tools thus, they are a catalyst in influencing the green building development. However, in contrast Aghimien et al., (2018)'s study showed that all their participants, who were from the Zambia's construction industry, had relatively poor level of understanding of green buildings. The study results show low utilization of tools and both Oke et al., (2019) and Aghimien et al., (2018) agree with these findings. In Developing countries utilization is low and this is a problem also seen in developed countries as well (William and Dair, 2016; Wu, 2019; Liu, 2022). In comparison with South Africa Zambia is lagging in rating buildings as their counterparts boast of an increase in the number of rated buildings (Venter et al., 2020)

The private sector had a higher likelihood to utilize tools than the public sector which was odd seeing that in most countries the public sector seems to champion GBTs (Gibbert, 2016 and Venter et al., 2020). The history of low-cost housing development in Zambia has demonstrated that there is minimal government engagement in attaining sustainable buildings, particularly because housing development has been left in the hands of the private sector as shown in studies like Makasa, (2016) and PMRC, (2018). Also, the need for government support is seen in studies such as Dahle et al., (2016); Jarnehammar et al., (2008); Al Khalifa, (2019), who mentioned that governments play a critical role in promoting green construction. By virtue of their size, government entities have more opportunities to invest in green projects and hence have a higher impact on communities than the private sector. GB can be promoted by active government interventions such as lowering energy pricing and providing financial assistance in GB s development.

The problem tree analysis showed that a lack of knowledge and educational and technical opportunities has a negative influence on Gb development, therefore, exposer to GB education and training can increases knowledge about GBTs. Knowledge of green infrastructure is a problem that cuts across countries and regions according to Aje, (2015). In comparison to developed nations there is more intake on GBTs than in developing nations like Zambia. However, in South Africa there is more use of GBTs, and the use of Green Star rating tool has increased interest and awareness of the possibility to develop green low-cost housing. South Africa leads the way in terms of green projects, as it boasts of having more than 500 Green Star certification, however the impact of these strategies on the development of green low-cost housing has not been felt in communities (Windapo, 2016; Oguntona et al., (2019); and Gibbert, 2016). From the South African experience, exposer to GBTs can increase both knowledge and interest in applying GBTs in low-cost housing. Other countries like Nigeria or Egypt also boast of having GBTs that are used in applying green strategies in their countries but when it comes to applying this knowledge in low-cost housing the implementation is poor (World Bank Report, 2016).

There is a need to increase training in the application of GBTs in low-cost housing development since utilization is low and all players of the building industry can be trained at different levels of involvement. This is supported by Abidin (2010) who mentions that the action toward sustainable application is determined by cautious movement, knowledge, and understanding of the outcomes of individual action. Therefore, if individuals are trained as assessors, this may increase opportunities for local GB assessments to be undertaken. Many experts in the construction sector are impacted by their exposure to information and activities on green buildings, and as this experience increases, interest in conducting assessments may grow.

Understanding GB is a critical first step in putting sustainable construction strategies into practice, even the Toronto Green Development Standard (2020), acknowledges that public knowledge about GB is a key factor in raising the demand for sustainable construction. GB challenges in underdeveloped countries is not just a lack of resources but also poor perceptions and knowledge about green buildings as seen in studies such as Zulu et al., (2019); Aghimien et al., (2018); and Bungau et al., (2022). Even though a high level of understanding of building sustainability did not translate into use, knowledge of GB may stimulate interest and motivate people to comply. The increased awareness of green building shows that most professions in the building industry are interested in issues of sustainable structures, but they lack exposure and access to GBTs. This is in line with studies such as Oke et al., (2019) who stated that interest in green building was high but there was no experience with them.

6.3 The Experience of the Respondents in the use of GBTs

The study sought to explore the experience of the respondents in using GBTs. This experience was based on several factors including: gender, years of experience, profession, sector of employment, projects undertaken, access and cost of GBTs, comprehensive use of tools and environmental adaptability. The results showed that the gender, sector of employment, projects undertaken, access to GBTs, and comprehensive use of tools were not significant to influence the respondents to participate in GBs. The null hypothesis for no association of factors in the use of tools was rejected as factors like years of experience, profession, cost of GBTs and environmental adaptability were statistically significant.

The qualitative results support these findings in that those with more years of experience contributed more to the interviews thus the use of GBTs increased with the number of years of experience. Few young professionals were engaged in GB certification in the survey due to the high cost of assessments and the low knowledge about the GBTs. The results in the study are similar to those seen in Bond, (2010); Windapo, (2016) and Assadiki et al., (2022), who had Architects that were keen to discuss GBTs than the other professionals. Thus, the profession is a factor and as such these professions can be instruments of change in the Green Building Movement. Because architects provide the most documentation in the certification process, training them in rating buildings could increase utilization. According to Cole (2019) green building education is prominent in architectural and engineering professions. However, the findings in the study showed that only a small percentage of professionals had received training in rating buildings and were qualified to undertake certification in Zambia.

Aside from gaining knowledge about GBTs, several factors can influence one's decision to use GBs. A person's demographic standing, industry experience, profession, or perception of the GBTs may all influence their decision to use them. Another factor that stimulated the use of GBTs is whether the users found them adaptable to the environment. According to the respondents in the research, adaptability to the environment was determined by applying design and construction strategies suitable for the local needs. The respondents mentioned that the current tools had some criteria that were adaptable but other criteria were not thus the tools could not be entirely used. These findings are in line with other studies that have demonstrated the need to have tools that are environmentally adaptable such as Fenner, (2007); Bond, (2010); Liu, 2020 Sun et al., (2019).

The study results showed that the respondents found GBTs costly, somewhat adaptable to the environment, relevant for some of the criteria, but comprehensive. As the evaluation cost increased, the likelihood of using the instruments was reduced. Most respondents claimed that the evaluation of building projects was regarded as a luxury by most clients or developers. Windapo. (2015) had the same argument that some investors felt that trying to make buildings as sustainable as possible comes with additional costs, and few clients are interested in going green. The LCAs incorporated in the tools tended to be data-intensive, and collecting and updating the needed data could involve high costs. Individuals who want to build sustainable buildings may not be able to get certification for their projects unless they are corporate entities since the cost of evaluation ranges from USD 2,150 to USD 8,500. Sun et al., (2019) supports these findings in that in their study developers felt that trying to make a building sustainable comes with additional costs and there is no market to take up that extra cost for going green. This is also in line with Ade and Rehm (2019) who mentioned that the hurdle to the implementation of many green building rating methods is a perceived increase in cost of assessment and construction of GBs. Few companies are involved in mass housing construction in Zambia, therefore, having a critical mass of people involved in green structure development will have a bigger impact on achieving GBs.

Perceived environmental adaptability increased the odds of utilizing GBTs. It was however, mentioned that the challenge with the current tools is that they have parameters that are not appropriate for the Zambian building environment. For example, the use of wood which is promoted in LEED and BREEM and CASBEE may not be sustainable in Zambia due to the poor management of forests. The promotion of artificial ventilation through the HVAC systems rather than natural ventilation is not relevant in Zambia as many users cannot afford such ventilation systems. There are criteria for improved refrigerant management, green power, and carbon offsets in the LEED system, which are too expensive to undertake. Tools that addressed the needs of the respondents in achieving GBs were preferred above ideas from outside the country not adaptive to the local environment, also supported by Fenner, (2007) and Bond (2014). The selection of SBAT criteria demonstrated the preference for local assessment instruments over those that were not. Therefore, GBTs developed in one country cannot be applied in another country without adjusting them. Thus, the adoption of criteria in the proposed tool under study was based on picking criteria considered adaptable to the environment. Assefa, et al., (2022); and Reed, (2011) also support this result. Bungau (2022) mentions the importance of having assessment tools that are region-specific or take into consideration adaptation to the locality. Liu (2022); Windapo (2014); Khani, (2021) stated that GBTs must be developed with criteria that will have the most positive impact on the environment.

Regional integration in the development of GBTs is cardinal because there is resource sharing and most environmental conditions are similar though not the same. The aspect of having too costly tools can be overcome if regional groups share the expense of developing local GBTs. Zambia belongs to regional groupings like COMESA and SADC, which have been promoting integration. Developing regional tools could benefit all member states, given that Africa has the least number of GBTs and the lowest utilization. Individual countries' efforts to develop their own GBTs have not yielded substantial results, and Africa continues to lag in the achievement of GB compliance. If GBTs are affordable and environmentally adaptable, the interest to utilize them by all parties in the building industry will increase and thus implementation of green low-cost housing will be actualized.

Comprehensive tools are those that cover all aspects of green building sustainability. The parameters for green building compliance differ from region to region, but every tool must cover all aspects of environmental, social, and economic criteria in line with international best practices. The odds of utilizing the tools increased when perceived to be comprehensive. As observed in the comparison study results, comprehension was obtained in ZIGBAT by combining all the related parameters from the various tools and merging them. This argument is supported by authors like Yudelson (2016) and Schendler (2010) who demonstrated that customers wanted genuine benefits from tools, hence, comprehensiveness permits the evaluation of criteria that provide genuine value to the users.

6.4 Environmental, Economic, and Social Criteria for Green Low-cost Housing

The results of the preferred criteria for evaluating low-cost housing rejected the null hypothesis, because respondents assigned different rankings to the criteria. Environmental sustainability was chosen as the most preferred criteria against social or economic. In the environmental group energy, water, health and wellbeing, material use were highly preferred, while in the economic group durability and resilience of building materials and local production of goods and services criteria were selected. In the social group it was security and facilities development. Literature has pointed out the need to have all the three arms of sustainability working together to achieve GBs as seen in studies such as Liu, et al., (2022) and Aquino et al., (2019).

In the problem tree diagram and in the theoretical framework the need to consider efficient energy and water use was outlined as a challenge hence the need to place them at the top of the hierarchy. In the environmental group energy had the highest ranking in both the RII and AHP priority matrix analysis and when compared with GBTs it is ranked the highest. Energy was given a high ranking because, like many developing nations, Zambia heavily relies on its natural resources to provide energy, and the indiscriminate use of these resources has had a negative impact on the environment. There is a heavy dependence on hydroelectricity whose supply is not adequate. These challenges have come about due to insufficient management of the natural resources as (Zulu et al., 2019) has shown. Energy in the SDG has been applied by ensuring access to affordable, reliable, sustainable, and modern energy for all. In the SHG energy has been applied by managing homes with energy efficient equipment, use of renewable energy, cutting carbon emissions, reducing the impact of power outages on the grid, and lowering the harmful health consequences brought on by pollutants from burning of fossil fuels. Although energy was ranked highest it was considered an expensive and complicated criterion to implement in GB as the results showed that energy in comparison with variables like easy to use and cost of installation was ranked lowly.

Health and well-being were rated second due to the internal health challenges that come with poor lighting, and poorly ventilated housing. More emphasis has been placed on the health and wellbeing of housing occupants with the emergence of diseases such as Covid-19. The high ranking of health and wellbeing is in line with Karimi et al., (2022) and. Kat et al., (2003) who found that a good internal environment brought about productivity in offices as well as housing. According to SDG there is need to improve the air quality, and this was applied by reducing the emission by using refrigerants with CFC and allowing for good air quality through cross ventilation.

Due to the high cost of construction materials and the difficulty of finding strong and resilient products on the market, material use was highly ranked as well. The usage of materials in SHG results was in line with the health effects from building material fabrication, lower material use, lower transportation costs, and more local employment due to production. In the SDGs material use is promoted by the construction of sustainable and resilient structures using local materials in the least developed countries, particularly by providing financial and technical help. This was applied by supporting community material production and skills development. Other criteria that were selected were solid waste management, pollution, transport, and sustainable sites.

The economic criteria which aim at supporting economic development while reducing the negative effect on the environment, was not well understood by the respondents in the study. The AHP results showed that efficient resources use and durable, resilience materials were highly ranked in comparison to local economy and local material production. Due to the high demand for resources in the building industry the respondents mentioned that it was important to reduce the consumption of the same products at source. The selection of durable and resilience materials was also highly ranked because durable materials reduce the cost of maintenance especially in low-cost houses and resilience materials are required due to severe storms experienced in cities. The problem tree diagram showed the absence of local materials and technical knowledge to manufacture and apply resilient and durable materials as a cause for unsustainable housing thus these results are in line with it. In the theoretical framework the economic criteria identified are market value and affordability. The theoretical framework expands the economic sphere by looking at the marketability of the buildings as well and the affordability of these green low-cost houses. The issue of cost of both the construction and the assessment of green low-cost houses has been placed as a factor because in the regression results the odds to select GBTs increased with reduced cost of assessment. Although the ranking of local economy and materials was low it was mentioned as a major factor in selecting GBTs.

In the SDGs economic sustainability is looked at as equality to economic resources and access to basic services and ownership of land. This has also been brought out in study such as Zulu et al., (2019); Phiri, (20160 and PMRC, (2018); NHP, (2019) where it has been shown that the challenge of attaining good affordable housing lies in having tenure to land. This is in line with the high ranking of efficient resources land being one of them. In the GBTs comparison the economic criteria were seen in DGNB, SBAT and SHG. In DGNB economic criteria is the efficient use of materials and services. While in SBAT it is about community participation and local economy, which is similar to SHG. It specifies products and services from the local area and provides ongoing employment in relation to maintenance and other services required within housing. These results clearly show that the issues of economic sustainability are firstly interpreted differently in each rating tool but also that most of them do not consider it at all. This argument is backed by Sala et al., (2015) who mentioned that the current tools have not done well in measuring social and economic sustainability. The proposed tool adopted this criterion and has defined it as provision of local building material production and diversification of financial activities to enable housing tenants to generate income through housing projects.

Security and safety were placed highly among the social criteria followed by facilities development taking into consideration the need to improve social interaction in housing communities. The respondents felt that security and safety as a criterion was easy to achieve and did not require high cost although its impact on GBTs was considered low. Although security and safety were highly ranked in the study, social sustainability in other studies is created through surroundings that assist communities in satisfying their social demands, which can include recreation. This is also mentioned in studies such as

Wilson, (2018); Pococka, et al., (2016) where social cohesion is achieved by creating surroundings that assist communities in satisfying their social demands. In the results recreation was not highly ranked but is an important social factor.

Some feel that the social and economic category has too many alternative interpretations, making it unsuitable for use. Various tools give different meanings to the social criteria. Based on the key informant, the social criterion included interaction spaces for communities such as parks, community halls, and walkways. Any activity that brings communities together for the common good was considered in the proposed tool. The problem tree diagram showed the need for safe, resilient housing and social cohesion. The respondents picked out safety as important parameters, and the difference in the preference could also have been the challenge of lack of knowledge on what constitutes social sustainability.

It can be inferred that several requirements for achieving social sustainability listed in the literature were similar to the needs of the respondents, in fact the odds to utilize GBTs increased with the inclusion of health and wellbeing and facility development, showing that the respondents considered these as important factors. In the GBTs health and wellbeing is not under social but environmental sustainability, some tools do not separate environmental from social aspects, for example in BREEAM, DGNB and Green Star security is found in indoor environmental quality. However, it is important to treat these criteria separately as each plays an important role in achieving sustainability. This is supported by MLG, (2016) and Pococka, et al., (2016).

The criteria that were chosen to be appropriate for the environment were those developed or often used in Africa like those seen in SBAT, Green Star, LEED, and BREAM. The differences in the criteria found in tools also proved to be a challenge in selecting which parameters to adopt. For example, LEED had measures like cooling tower water use, demand response, and environmental tobacco smoke, which were not seen in other tools. Common criteria were isolated and adopted into the proposed tool being energy use; health and well-being, water management; material use; pollution control; transport; and sustainable site. In the energy category, the use of renewable power like solar was found in most of the GBTs. Saving energy in Green Star and LEED is achieved by energy metering and energy-efficient equipment. Energy efficiency contributes directly to environmental sustainability and lowering utility bills from buildings increases their benefits. However, in underdeveloped countries like Zambia, energy metering and energy-efficient equipment may be difficult to achieve since the culture of checking such readings is not common. Even though energy was listed as the most important criterion, particular indicators such as HVAC, artificial heating and cooling systems, and energy metering systems were not considered feasible in the Zambian low-cost housing due to the high installation cost of the equipment.

Designs take on the context from which they are being applied, thus, local climatic conditions influence the outcome. Due to the climatic conditions, for example, the practice of using large windows facing the direction of the prevailing winds is now commonly used in Zambia. Some strategies offered in GBTs, like the control of tobacco smoke in buildings, come with high detection equipment and maintenance costs, which can be expensive in low-cost housing. Green strategies need more commissioning and maintenance than standard services; thus, only achievable strategies should be adopted in green building development. Studies like Assefa et al. (2022), Reed (2011), and Bungau (2022) have made the case for regional adaptability by stating that it is crucial for tools to consider the specific contextual characteristics when deciding on the criteria to utilize for rating.

Water management in GBTs encourages the efficient distribution of the commodity with very few leakages along the supply line. Water use was selected to be ranked highly because it affects the achievement of green low-cost houses. Zambia has erratic and poor quality water supply challenges thus the need for efficient water supply is seen as an important sustainability issue. Other studies have also shown how important water efficiency is in Zambia. For example, UNDP, (2020); Phiri, 2016; and Munshifwa, et al., (2021) show that Zambia continues to face difficulties in ensuring environmental sustainability due to drought, and low delivery of clean drinking water, and sanitary facilities.

The material and resource criterion were highly ranked, but as seen in other GBTs wood was not promoted as the most important sustainable material due to the unavailability of sustainable wood sources but rather local earth blocks were suggested instead. Most of the material selection included local resources; recycled construction materials like broken concrete blocks and tiles; compressed earth blocks; flexibility in material use; low embodied energy resources, and these came from SBAT and SHG. This selection is supported in studies such as Windapo, 2016 and MLGH, (2016), where they advocate for the use of local materials to achieve sustainability.

Land use and ecology were some of the categories that were included in the tool. This was achieved through landscaping to boost the site's value, as illustrated in both CASBEE and SHG. This criterion had a good score across all tools, indicating that it was highly valued. The land use criterion must be considered based on the situation on the ground and the factors affecting users. To respond to this difficulty, the solution in SHG was to preserve the current valuable trees, plantings, and ecosystems and place housing in urban boundaries to avoid wastage of land. However, individual site development can adopt strategies shown in the GBTs, which include control of air; noise; and light pollution. It also calls for the protection of existing features of ecological value on sites. To prevent run-off to natural watercourses, wetland areas are to be protected by cut-off ditches and site drainage. The criteria for using recycled materials on site were taken into consideration and ease of access to places was considered as a beneficial contribution to decreasing the carbon footprint. The tool included transportation since the respondents assessed it fairly. The solutions included housing should be close to public transport nodes, cycling tracks, and public services. Other factors to consider are parking lots and secure bicycle storage to avoid overuse of eternal space and reduce impervious surfaces to allow for surface water drainage as seen in SHG and LEED tool.

The respondents in the study felt that if all the necessary criteria were to be applied then an integrated system was required to achieve this. Also supported by As Kaatz et al. (2007) who stated that rating tools should be built with integration, transparency, and accessibility in mind. The research discussion leaned towards an integrated approach with an emphasis on regional-based assessment. The integration was between CASSUD method and selected criteria. When developing the ZIGBAT, the issue of accessibility and integration was considered, as the tool incorporated several criteria judged to have local content and was accessible to many professions due to the cost reduction of materials.

6.5 The Factors Associated with use of Green Building Tools

Environmentally adaptable tools, comprehensive tool, and cost of assessments, presence of government regulations, environmental benefits of green buildings, market for green products and high return on of green buildings were the identified factors in the use of tools. The descriptive results analyzed factors ranked from RII and AHP and included: financial (Tax reduction of GB products); governmental (presence of regulations and policies); and environmental (environmental benefits of GB by the users); and cultural and market (improved market for green products and materials). The least factors were publicity and campaign, and reduced LCC. These results are in line with other studies such as Assylbekov et al., (2021); Darko et al., (2017); Ali et al., (2016); Liu et al., (2022); Alsanda (2015); Zulu et al., (2019) who showed that there is lack of legislation and laws to mandate the use of GBTs. Also, the high initial investment in GB, technical knowledge of GBTs in housing, and lack of significant demand and supply of GB influence the use of tools. The inferential analysis results showed that the factors that were significantly associated to the use of GBTs were: high return on investment, economic incentives, sustainable building byelaws, and technical knowledge. The results in both descriptive and inferential analysis all pointed to the importance of economic support, government laws and participation and knowledge about GBTs.

6.5.1 Tax reduction on green building products

Some respondents in the research mentioned the need to have cheaper green building materials and opportunities to get special loans for GB development. Since the government is the largest client in the housing industry, there is a need for them to offer several finance options that can meet the needs of the users such as tax relief on green building construction. The example of such reliefs includes Certified Emission Reductions (CER) where the government may offer tax exemptions on green materials or carbon emission tax. Such incentives have been mentioned in Assylekov et al., (2013) and Oguntona et al., (2019), who mentioned the need to have emission reduction taxes to encourage the use of GBs. This indicated that there may be an upward trend in the promotion of GB if the government intervened and supported important stakeholders in the construction industry.

6.5.2 Lack of regulation and policies on green building tools

The lack of legislation and policies to guide the use of GBTs was highlighted in the problem tree diagram and the theoretical framework and was the most significant factor, followed by the high initial investment in GB in both the questionnaire survey and interview results. Other studies support these findings such as Dahle et al., (2016); Zulu et al., (2019); Ametepey et al., (2015); and Darko et al., (2017) who showed that there was a relationship between bylaws being available and utilization of GBTs. The majority said that regulations were needed to govern how construction work may be done sustainably and to obligate developers and clients to use GB techniques. There was consensus that the issue of sustainability was being encouraged by the government, however, the efforts were too broad to be effective. The lack of laws supporting GBs in the study results have been supported by Kumar and Pushplate (2017) who argue that the current laws are rigid and stringent and have not been updated to include green infrastructure. Changing needs of the environment, such as low energy costs, recycling, or reuse, are not considered either. According to one participant in this study, the building codes even prohibit green building practices such as the use of burnt or mud bricks in dwelling construction.

According to the respondents in the study, the absence of bylaws and specific policies on GBs in Zambia negates the obligation to apply green building strategies. The key informant stated that current building codes and regulations do not meet the changing environment which require experts in the building industry to examine a variety of environmental and social and economic parameters in their design and construction of housing. They went on to say that several bylaws were against the promotion of GB principles, as they limit the use of green materials like wood and clay bricks in the urban areas.

The government plays a key role in enforcing regulations, changing legislation and policies, building codes, incentives, and other financial instruments to encourage sustainable construction. Due to a lack of governmental direction, professionals believe that they are not obligated to implement green building solutions in their structures unless there are feasible benefits. Other literature supports these finding in that the lack of policy and industry guidance, the immature market environment, and the lack of environmental awareness are the most important negative factors to the growth of GBTs (Ametepey et al., 2015; Darko et al., 2017).

Developing countries heavily depend on government support and leadership in promoting new strategies. It is no surprise that lack of government policies would be associated with poor use of tools. Another issue is that there are no regulations or policies in place to steer the course of sustainable building development, and there are no measurable milestones by which sustainable projects will be managed. This is supported by Alsanad (2015); and Darko et al., (2017) who showed that an absence of laws for GB results in low compliance.

The role of governments in supporting green construction is critical and proper policies and regulations should be put in place to assist GB growth. Other studies such as Qian and Chan (2010), support this result that countries with green legislation play an essential role in the GB Movement. Even though educational programs were deemed essential components in promoting and expediting efforts toward green and sustainable projects in Kuwait (Alsanad, (2015) and even Sabiu (2020) mentioned that other important aspects include defined laws and legislation. In developed countries. GB construction has increased due to the rising number of building regulations and policies mandating energy-efficient structures in countries like South Africa as Venter et al., (2020) has elaborated in their study. As a result, a market for environmentally friendly and energy-efficient materials for residential construction has emerged. When it comes to GB standards and policies, they cannot be looked at in isolation without considering government engagement in providing incentives to adhere to these policies.

6.5.3 Environmental benefits of green buildings

The environmental benefits of GB included minimized energy use, health and wellbeing of occupants, water management, sustainable sites, pollution, and waste management. The respondents in the research chose these as factors based on what they thought would attract their clients and developers to adopt GB compliance. However, they were quick to point out that data on the environmental benefits of these criteria could only be forecast if buildings were appraised and environmental values measured. According to the key informant in the study, clients are more likely to comply with GB regulations if they are aware of the environmental benefits. Rising energy cost was a major factor in some studies whereas the findings in this study included other environmental benefits like water management, waste disposal, the creation of healthy, safe buildings and use of sustainable building materials. Unlike Windapo (2014) who found health and well-being to be the least important driver, it was not the case in this study's findings in that environmental benefits were a key motivation. The key informant in the study emphasized environmental over social and economic criteria due to limited experience or knowledge of the social parameters, as seen in the interview results. Therefore, the more familiar the professionals and clients were with the other criteria, the more likely they would promote them in achieving GB compliance.

The need to reduce energy cost as a factor was supported in the study interviews as three of the key informants mentioned energy reduction as key to sustainable buildings and gave examples such as the use of biogas and solar energy. This is in line with other studies such as Spera, Magazine, (2020) and Luangcharoenrat and Intrachooto, (2018) who selected rising energy costs, monitory benefits of reduced energy consumption, building codes, tenant satisfaction and competitive advantage as factors associated with enhancing GBs.

Although some of the associated factors in this study were different from those observed in other research, similarities were seen in choosing rising energy costs, financial gain due to reduced cost of the construction of the buildings, and improved occupants' health and wellbeing. The lowest rated factor was publicity and campaigns on GBTs. The importance of publicity and campaigns was seen more in organizations than in individuals. The lack of green initiatives that are quantifiable or demonstrate the benefits of rating buildings contributes to the low publicity of GBs.

The health and well-being of the occupants included the ability to have buildings that allow natural ventilation, good internal air quality and less harmful building materials. The benefits of water management were meant for clients to have an adequate supply at an affordable price and to reduce their dependence on the local utility companies. Some of the key informants mentioned that if they could show proof that GB will reduce the cost of services in buildings, developers and clients would invest in them.

The challenge in achieving sustainable sites was because of the poor land tenure system. The study respondents mentioned that attaining land is difficult thus people have no choice but to acquire land which is not meant for housing development such as water catchment areas. Poor land tenure as a factor was supported by MLGH, (2016); PMRC, (2018) where they stated that poor land tenure was affecting the development of sustainable housing.

The respondents did not discuss pollution due to limited knowledge of what constitutes pollutants. Waste management was discussed more intensively since all of them are affected by the poor waste management in the cities. The key informant mentioned that if waste management could be tackled in GB, this would be a positive factor as many clients were battling with poor garbage collection services. The study findings were in line with Oguntona et al., (2019) who identified the top five benefits of GB project implementation as improved indoor air, ecosystem protection, higher energy efficiency, improved health, and well-being of inhabitants, and reduced solid waste.

6.5.4 High cost of assessment

The initial cost of establishing GB rating deters many people from participating in green infrastructure projects. For many, the feared cost of green structures is compounded by the fact that the evaluation procedure is equally costly. The findings in the study revealed that undertaking a green building assessment costs more than USD 2,000, and to be a qualified assessor, one must pay more than USD 2,000 to get a certificate. The initial cost of green infrastructure is usually high, and many clients do not look at the long-term benefits, thus they opt not to include them. GBAs are costly, which raises the price of green infrastructure. Most building projects are run on a stringent budget, and the perceived increases in the cost of green projects are not attractive for most private developers. The key informant mentioned the high cost of assessment and assessor training as a hindrance to the use of tools. There was a link between tool use and a perceived high cost of evaluation among the study's respondents. The high incremental cost of GBTs, the poor recognition of sustainable development, and the lack of cost-effective technologies were also identified as negative factors. Most respondents (83percent) in the study stated that they could not afford to conduct an assessment despite their desire to do so, implying that low-cost GBTs could reduce the perceived high cost of GB development.

Green building finance is better mobilized through institutional investment (World Bank, 2018). Financial institutions require incentives to expand their client base, and the creation of green goods through banks could boost the development of green structures and products as seen in other studies like Matisoff et al., (2016), Smit, and Du Toit, 2015) where the initial cost of developing sustainable structures is high, many inventors seek financial backing from either the government or lending institutions. Local based finance for GB is more sustainable than external finance. These may include the promotion of locally produced materials and designs. Large corporate clients, such as those in the manufacturing industry, power utilities, property, tourism, transportation, and municipalities, may require long-term financing. The availability of cheap finance will have a ripple effect on the implementation of GB as it will cater for both actual construction and assessment. The presence of data on assessed buildings is another factor, as it can offer consumers confidence in the benefits of GB because they can see documentation rather than dealing with theories.

6.5.5 The lack of technical skills

Most respondents in this study stated that they could not carry out GB assessments because they lacked technical capabilities and knowledge transfer was inadequate. The lack of capacity in the construction sector to implement sustainable practices is a prominent factor and others such as Onososen et al. (2019); Assadiki, (2022); Huang et al., (2018) and Liu et al., (2022) mentioned a lack of knowledge, understanding, and information as the major factor to the delivery of sustainable structures. The findings demonstrate that, while professionals were informed about the fundamentals of sustainability, they lacked specialized expertise in rating systems and how to conduct green building inspections.

The respondents were aware of the concepts of GBTs but there was low usage, therefore a lack of expertise and abilities to conduct a GB evaluation was a key factor as seen by, Oke, et al., (2019) who established that a lack of awareness and knowledge of sustainable construction (SC) practices among construction professionals in Zambia was a major factor. Alsand (2015) concurs with this study's findings and showed that a lack of knowledge by professionals affects the use of tools.

6.5.6 Market-based factors

The other highly ranked factors were market-based, improved market for green products and materials, high return on investment, increasing property values and the interest of developers in GBTs. Most of the materials that are considered sustainable are not labelled as such therefore very little is known about green products in construction. Many manufacturers of construction materials are working at getting their products labelled green, therefore Zambia has not reached levels were there is an availability of green materials on the market, also supported by Zulu et al., (2020). Affordable green products and materials were the most important economic factor, followed by a high return on investment. Developers of housing expect to make profit from even green low-cost houses therefore high returns on such investment is an important factor in the promotion of GBTs. Other studies have supported the need for affordable green materials like Anshebo, et al., (2022), and Windapo, (2016). The real benefits of green buildings must include both environmental, social, and economic, although the economic benefits are not felt immediately but over time. Publicity becomes important so that users are aware of these benefits.

Some of the respondents in the study felt that green compliance can be achieved by promoting the economic benefits of GB to either clients or developers. GB with low total energy costs, low water use, and acceptable internal air quality could be a selling feature for their use. The study's findings are consistent with those of Zulu (2019), who showed that while the initial cost of GB was high, the long-term benefits outweighed the initial cost, and this could attract clients to develop their buildings sustainably. Clients are a big player in influencing GB as they have the final say on the type of buildings to be constructed. The client's influence in green building development cannot be overstated, as this has been seen across the country, where innovative designs are shared among developers and tenants. Clients can give feedback on their experiences living in GB, thus raising awareness about the benefits. These profits may include low operating and maintenance costs and low energy consumption. These findings are in line with Häkkinen, and Belloni (2011); Darko et al., (2017); and Serpell, et al., who stated that client acted as a catalyst for the promotion of GBs and reducing environmental impact of building construction.

6.5.7 Publicity and campaign

The key informant in the study said that there was relatively little literature on GB, and more publications and campaigns were needed to spark awareness. According to the key informant, publicity, and promotion for GBTs were regarded as major factors, although it was ranked lowly by the respondents. They further stated that GB was a new phenomenon among the professionals and even worse among the public. There was a need to showcase GB projects in Zambia and educate both specialists and the community about assessment tools. Despite publicity and campaign being the least factor, there was evidence that there is lack of knowledge, understanding, and awareness about GB in the study population. The poor knowledge and abilities in GB compliance could be due to an absence of green building publications in Zambia.

Publication and campaigns also contribute to the dissemination of knowledge. There is more publication about GBTs among the private consultants than the public entities. As per survey respondents, low public sector engagement is attributable to the government's lack of involvement in supporting GBTs. LEED was the most used tool in Zambia among the various applications available. Some of the factors behind the use of the LEED tool included popularity and promotion from outside the country. Several rating tools have not been used or are unknown due to a lack of visibility and publicity in underdeveloped countries, also noted by William and Dair, (2016). The poor use of the SDGs could also be contributing to poor GBTs use in Zambia as has been reported in the study. The SD performance of African nations was found to rank lowest around the world. This means that a lack of application of the goals results in poor achievement of GB strategies.

Training could stimulate interest among the professionals and could be a catalyst to draw them towards GB achievement in their projects. strengthening publicity and education may be an effective way to enhance public awareness of environmental sustainability as well as customers’ willingness to pay for it. Advertisements should be accompanied by education, especially for those who are directly involved with the utilization of GBTS, according to the findings in the study. The key informant mentioned that they would like to be educated on green building compliance, but few opportunities were available. As a result, separate programs might be created for different participants. Some require GBTs training, and others require a basic knowledge on GB.

Many respondents in this research believed that there was little public awareness of GB in the country and that despite the abundance of information available on the internet, few felt compelled to use them. Some schools of thought claim that publicity on GB should be targeted at the parties that interact with the GBTs, while others felt that it should target the general population. The information should be made available to anyone interested in GB, but the depth of information may differ depending on the needs. As has been argued in the literature review, green building compliance will only be achieved when all the sectors of society are involved in achieving it. Because many governments in developing countries have limited capacity to achieve green construction, individual efforts in green low-cost housing development are required. Publicity campaigns must be carried out to educate people at different levels of involvement in GB. Professionals feel that specific information such as access to GBTs and opportunities for training needs to be made available. Publicity and campaigns are suitable for the general population, but professionals want to be able to access GBTs and to be equipped enough to undertake GB assessments.

The type of campaigns and publicity undertaken matters, as people's level of understanding differs. To achieve GB compliance, multiple stakeholders that impact utilization must be targeted. For example, even if experts wanted to develop GB, they would require financial backing from their clients. Clients' awareness of the benefits of GB is increasing, so publications and campaigns should target both clients and professionals. Publication and campaigns are meant to showcase the benefits of GB, however, many of these green strategies are beyond the reach of many people developing low-cost houses. Other studies concur with these results in that the factors for adopting GB include a good public image. In most developed countries, many clients are aware of the benefits of GB rating, and they use these structures as a selling point for higher rentals.

The key informant in the study did not find all the criteria in GBTS to be in line with the aspiration of the users, thus it is important to understand the GB aspiration of the stakeholders. The factors in Darko’s study had both environmental and economic incentives to develop GB, where developers and clients were more concerned with the value addition due to the green tag, which attracts higher rentals or raises the market price of the housing on the market. To some extent, the results in Darko’s study were similar to the results in this study where environmental and economic benefits were considered important (Darko et al., 2017).

6.5.8 Application of green building rating tools

The comparison of the various GBTs, SHG and the SDG was necessary to develop a local tool that factors in all the best practices of GB sustainability. Environmental performance of the entire building across its life cycle, social, economic criteria, integrated whole-building design, and regional technology and materials were among the strategies chosen. It can be deduced that the order of preference of criteria seen in the proposed tool depicted the respondents' preference and is in line with the best practices in GB assessment.

The proposed tool was designed for assessing the percentage compliance based on the environmental, social, and economic criteria. It has enough information on green building techniques and procedures to plan and create sustainable housing projects. The tool adopted simple and affordable techniques that could be applied and quantified. Some of the criteria included detecting household energy and water consumption per month through rainwater harvesting, use of solar energy through photovoltaic panels and measuring the energy gained. The social criteria were mostly adapted from the SBAT tool and the SHG, where durable and resilient locally produced building materials are demonstrated. Social cohesion is encouraged and the creation of recreational spaces that enhance interaction. Access for the disabled into buildings was considered by providing ramps and elevators in multistory buildings. To achieve economic benefits from GB, the proposed tool advocated for tenants and craftsmen to be trained in GBTs so that they gain business opportunities from such projects. Another economic benefit was the adaptation of effective material use on-site to reduce wastage and recommendations for house construction utilizing local building materials and labour. Studies such as Windapo, 2016; Darko et al., (2017) have shown that it may be more cost-effective to use local materials rather than materials that are supplied from afar, reducing transportation cost while also benefiting the environment. Flexibility in the design of the houses would promote multi-use, thus spaces can be created to conduct business in the housing complexes. Another factor adopted was education. One of the causes for the low utilization of GBTs was a lack of knowledge and affordability of GB assessment. It was concluded that education in green construction can increase interest in attaining green compliance. Developing a tool for GB evaluation can help individuals become more involved in achieving green compliance.

6.5.9 Application of the Zambia integrated green building assessment tool

The novelty of the tool was the integration of various methods and criteria that respondents preferred in the questionnaire survey, interviews, the GBTs, SHG, the and the 11th SDG. A new assessment tool that was easy to use but appropriate for the Zambian building industry was created. Embedded in the tool were calculations of lighting requirements and the quantity of rainwater that can be collected. The appropriateness of the tool was the adaptation of the best practices in GB as well as capturing the aspiration of the building experts. The tool also incorporated several features of GB that were adapted from the SHG to actualize parameters in the guideline that many professionals do not use. It was possible to develop an assessment tool that translates theory into practice and produces results that can be implemented on the ground. One of the NHP goals was met with the establishment of the tool that is, enabling the production of GB based on national standards.

The WGBC pushed for the creation of local assessment tools that follow best practices in GB development while also reflecting national goals. The development of the tool answered this aspiration because, it promotes the application of GBTs in Zambia appropriate to the country's situation, culturally, climatically, and economically. The tool answers the question of having accessible and affordable tools for Zambia. The experts' verification results showed that they found the Tool useful and could bring some green elements into the housing market. Some evaluators from the study viewed the tool as an answer to the challenge of using long and complex tools. Its suitability was demonstrated by the fact that 3/5 of the experts said the parameters applied to Zambia's environmental and conditions. There were proposals for the tool to incorporate separate interfaces with details for calculating lighting and airflow designs, while others said it should be developed further into a rating tool.

Rather than focusing on rating buildings, the tool demonstrated its ability to be used for selecting strategies and materials that can help to achieve green low-cost houses. It was vital to go in that direction because the study's findings revealed that GB solutions were rarely considered in Zambian housing development. A practical tool for planning and assessing GB in Zambia was provided in the tool thus filling a research gap. The literature review exposed the necessity for national or region-specific tools, and the tool addressed that as well. It is a step towards applying the theories seen in the 11th SDG, SHG and SBAT.

6.6 Validity of the Results

The instruments used to collect data aided in interpreting the paradigm of pragmatism in that different methods and analytical tools were used to achieve the objectives. The usage of RII, correlation, and regression analysis, for example, had quantifiable results. The different data gathering tools, such as the questionnaire survey and interviews, were suitable for the study's objectives. The Likert scale, for example, yielded similar results to the qualitative interviews in terms of demonstrating poor utilization. Factors associated with low utilization from the regression analysis were consistent with the interview results. The Likert scale was used to measure knowledge levels. Logistic regression was employed to analyze the relationships between variables. The hypotheses were checked both in the regression and with the Mann Whitney test. These tests were correct and objectively proven. Both internal and external validity were tested because experts in the building industry validated externally the results.

6.6.1 Reliability

The instruments used in the proposed tool design were comparable to those employed by Abu Bakar and Cheen (2013), CASSUD, and Gibberd's SBAT development. The study design and the results in investigating the factors associated with GB were similar to those used by Ntshwane et al. (2014), who explored the environmental and economic obstacles to green development in Botswana, and Aghimien et al. (2018), who investigated the impediments to constructing green infrastructure in Zambia. The mixed-method design helped to demonstrate reliability as the results from the various studies complemented the study.

6.6.2 Generalizability

The results in the study can be generalized to the population because the various professionals that took part produced similar results on the factors associated with the use of tools. Other studies also supported the results in that the challenges faced concerning rating tools were similar across the continent. The criteria rating in the tool can be applied to any site or region, and the assessment results will be similar.

6.7 Limitations of the Tool

The tool had limitations in assessing green low-cost houses as only descriptive results were produced for the parameters that were not scaled. Some of the building materials and strategies included in the tool were not available on the market but were considered appropriate for the development of GBs. Detailed assimilation programs like lighting designs and air flow charts or LCA calculators were missing in the tool thus demonstration of those concepts was not available. However, some of the limitations can be overcome with further improvement of the current tool.

6.8 Limitations of the Study

The study had limitations that need to be considered when interpreting the reported findings as follows:

i. The study did not go further to test the tool on real projects but relied on expert opinion. However future studies may be undertaken where green projects are assessed;
ii. validation of the tool only took place with some members of the building industry;
iii. there were vital people not included in the study such as the communities who occupy low-cost houses and the local authority;
iv. The research was limited to only two provinces, thus the experience of the other players in the remaining provinces was missed out. In future research could include other provinces and;
v. The software for the tool was limited in that it could not be used to develop graphical presentation of the GB solution as most of the results were descriptive. This hurdle could be overcome by improving the current design.

6.9 Summary

Chapter Six presented the discussion of the results for the realization of a green housing assessment tool. Literature review, comparison study results, interviews, and questionnaire survey results regarding factors associated with the use of tools, criteria selection, and the creation of a GB tool was examined in relation to local and regional sustainability requirements for buildings. Understanding environmental, social, and economic, and cultural issues to achieve GB in Zambia provides a systematic and recorded approach for establishing a tool for evaluating low-cost housing. The ZIGBAT has the prospect of aiding the accomplishment of sustainable houses in Zambia by giving practical steps of selecting and applying techniques and materials that are considered sustainable for the region. The tool provided a standardized procedure for assessing green low-cost houses in Zambia which can set benchmarks for SADC countries. Chapter Eight presents' conclusions, recommendations, and limitations of the study and highlights areas for further research.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

The results of the questionnaire survey, interviews, and in-depth desk top studies were discussed in Chapter Six. The discourse focused on GBTs usage and knowledge in Zambia, as well as associated factors to the application of GB. Developing a green building tool for Zambia was also deliberated. Many respondents were discouraged from participating in green construction projects because of a lack of knowledge and experience in rating buildings. The study findings showed that some of the criteria in the tools were inappropriate for the Zambian building industry, and the expense of certifying structures made the tools unaffordable. An integration of CASSUD framework, SHG, the 11th SDG and criteria from GBTs were used to develop the ZIGBAT.

The objectives of the study were all met successfully. Adaptation of GBTs is key to the actualization of green low-cost houses in Zambia. Identification of the factors associated with the use of GBTs is vital in the implementation of green low-cost houses in areas where poor housing is evident. A tool was created to evaluate and plan green low-cost houses after consulting with the stakeholders in the building industry to determine the factors they believed were crucial for achieving green low-cost housing. The research was set out to:

i. establish the knowledge and utilization of GBTs among the professional in the Zambia building industry;
ii. identify the factors associated with the application of GBTs;
iii. establish the preferred environmental, economic, and social criteria for assessment of green low-cost housing.
iv. and develop a tool for evaluating green low-cost housing in Zambia.

7.2 Conclusions

Zambia's housing deficit and poor service delivery has contributed to the rise of unsustainable housing development. Government disengagement in the construction of low-cost houses left the development of sustainable housing in the hands of individuals who lack resources and services to achieve GBs. Building materials and their supporting infrastructure are unaffordable making low-cost housing unreachable to the urban poor. There is indiscriminate use of natural building materials affecting the environment negatively. There is an absence of GBTs due to low knowledge and poor state implementation of the housing policy. This has promoted unsustainable building habits as communities strive to deliver housing with little or no technical and financial support.

7.2.1 Knowledge and utilization of green building strategies

The respondents varying levels of knowledge or technical experience of GBs suggests a lack of education and training in the use of GBTs. There are currently no developed local tools and even the existing tools are poorly used in low-cost housing development in Zambia. In contrast to South Africa, which has adopted a GBTs and has turned SBAT into a local evaluation tool, Zambia has not done well in promoting and supporting the establishment of GBTs. There is no government involvement in coming up with guidelines or regulations specifically for the development of local GBTs. Lack of government involvement and poor marketing affects utilizing of GBs in the building industry. The low utilization of tools was seen across the study population demonstrating poor utilization of GBTs. The issue of environmental adaptable and appropriateness of criteria was raised as a factor that determines which tool will be selected as tools like SBAT and SHG were preferred due to the regional proximity.

7.2.2 Factors associated with the utilization of green building tools in Zambia

There were financial, environmental, government and market/ cultural factors identified. The variables that were significant were cost of assessment, public interest, technical knowledge, high return on investment, tax reduction, economic incentives and building bye laws. There is need to have different training for the various professionals in the building industry due to poor skills development in the study population. Government needs to get involved in facilitating incentives such as tax reduction, and green loans if the utilization of GBTS for low-cost housing is to be actualized as seen in developed countries. Other factors were publicity and campaigns, government incentives, affordable tools, and regulation to promote the use GBTs, education or skills training on GBTs and the promotion of green sustainable materials.

Reduced energy consumption, occupant happiness and well-being, water management, sustainable sites, pollution reduction, and waste management were some of GB's environmental benefits. While some of the study's factors were distinct from those found in other research similarity was seen in growing energy costs, financial gain from lower building construction costs, and better occupant health and wellbeing, as factors associated with use of GBTs. The environmental factors receive more attention than the social and economic criteria in GBs.

The upfront costs in GB ratings and assessment training add to the cost of green structures. Most respondents in the survey were unable to conduct GB assessments because they lack the necessary technical skills, and knowledge transfer was insufficient. Poor financial support in developing GBTs is contributing to the poor number of assessors of GBs in Zambia. The cost of bringing in assessors from outside the country makes the assessment of GBs more expensive.

The other preferred factors were market-based, improved market for green products and materials, high return on investment, increasing property values and the interest of developers in GBTs. Green products and materials were the most important economic factor, followed by a high return on investment. There is relatively little publicity for GB materials and techniques thus low interest from both the professionals as well as the public.

The tools chosen to be environmentally adaptable were those developed or often used in Africa, like SBAT, Green Star, LEED, and BREAM. The availability of all-encompassing tools increased the odds of utilizing them. Countries with green legislation play an important role in being one of the GB Movement's main engines. Building bylaws have not addressed the environmental and social and economic concerns that must be applied to achieve sustainable structures. Affordable tools are required in developing countries and governments should support efforts at the development of local rating systems.

7.2.3 Environmental, economic, and social criteria for assessment of green low-cost housing

All the highly ranked criteria for use in green building assessment for low-cost housing were as follows:

i. Energy,
ii. water,

iii. health and wellbeing,
iv. material use,
v. sustainable site,
vi. solid waste management,
vii. pollution,
viii. Security
ix. durable, resilience materials
x. local economic growth and local material production

Local climatic conditions influence the choice of which environmental parameters to use in Zambian. Efficient energy and water use was outlined as the most preferred due to the scarcity of the commodity. Natural ventilation was promoted rather than the use of HVAC systems and energy metering and energy-efficient equipment may be difficult to achieve due to cost.

Health and well-being were rated second due to the internal health challenges affecting the urban poor. The odds to utilize GBTs increased with the inclusion of health and wellbeing and facility development. factors. Due to the high cost of construction materials and the difficulty of finding strong and resilient products on the market, material use was highly ranked as well. Other criteria that were selected were solid waste management, pollution, transport, and sustainable sites.

Efficient resources use and durable, resilience materials were highly ranked in comparison to local economy and local material production. The empowerment of local communities to lower the cost of green low-cost housing was sighted in the study. Safe, resilient housing, social cohesion, security, and safety were placed highly among the social criteria followed by facilities development and improved social interaction in housing communities.

Most of the material selection included local resources; recycled construction materials like broken concrete blocks and tiles; compressed earth blocks; flexibility in material use; low embodied energy resources, and these came from SBAT and SHG. Land use and ecology were some of the categories that were included in the tool. Accessibility criteria was applied by providing public transport near housing.

7.2.4 Development of the tool for assessing green low-cost housing in Zambia

The development of the ZIGBAT was the study's climax. It was proposed that integration, transparency, and accessibility be key in its development. The research discussion leaned towards an integrated approach with an emphasis on regional-based assessment. The integration was between CASSUD method and selected GBTs criteria. It was created with the PHP programming language (2015). An excel sheet was generated where the three arms of environmental and social and economic sustainability could be applied. All the statistically significant variables were ranked into the tool using AHP tool. The tool's output was scaled as a percentage of green compliance, and the results were descriptive and quantitative. Because it was online based, it could be accessed from any web browser on a computer, tablet, or smartphone.

It had eight categories: environmental, social, economic, education, management, and innovation. regional priority, community participation and education. The tool can calculate or describe how to achieve the following:

i. detects household energy consumption from electricity bills and calculates the size, type, and electricity quantity of photovoltaic panels;
ii. It measures water consumption per month and reduces water use through reuse of greywater and rainwater harvesting;
iii. use of local materials with low carbon footprint;
iv. planting on site with low / appropriate water requirements;
v. encourage public transport, walking and cycling;
vi. use of natural cooling and heating/ cross ventilation semi open spaces/ verandahs;
vii. promotes education/ health and safety, social cohesion, green spaces and resilient buildings;
viii. diversification in housing use to create wealth;
ix. promotes local experts and tradesmen in GB;
x. education of tenants, tradesmen, professionals, and clients;
xi. occupants of buildings are introduced to occupation building manuals and green building maintenance; and
xii. access for the disabled into buildings was ramps and elevators.

Each of the categories had a complete selection of criteria, and data could simply be imputed and uploaded as needed.

7.2.5 ZIGBAT validation

A first stage validation process was undertaken in that it was created in accordance with ISO9001 standard; the criteria ranking was through AHP Transparency Choice software, which minimized error. The tool was also verified by expert opinion. A second validation process may be the scope of future research, which was beyond the extent of this study. This would include other players in the building industry like the communities, clients, and planning authorities. Because the tool was not evaluated on an actual project, its performance was restricted to the assessors' observations.

7.2.6 Recommendations

Arising from the above conclusions, the following were the main recommendations focused on applying the tool in planning, designing, and constructing sustainable, low-cost housing:

a) Integration of the tool in the bylaws

To integrate the ZIGBAT into the building bylaws, as an annexure to the document or used to revise the current laws.

b) Use of the Tool by members of the building industry

The building industry members can be trained in using the tools in the following:

i. a supplement to architect’s practice manuals, the tool could be used in the design or planning process;
ii. The ideas shown in the tool could be reflected in the drawings and included in the design and construction of green low-cost houses;
iii. The tool could be exposed to all parties in the building industry and demonstrated to various professional bodies;
iv. The creation of a GB library in which variables could be saved and modified as needed; and
v. Financial institutions could offer this tool as part of a loan package.

c) Government involvement

Government are the biggest players in the building industry and thus they need to be engaged in promoting and enforcing green building activities as detailed below:

i. The government could also use the tool to update the building bylaws and may add the information from the tool into revising the National Housing Policy;
ii. Mandatory laws for housing projects with GB strategies from the tool that are attainable and affordable;
iii. The training of GB assessors locally could be mandatory so that local evaluators are part of the assessment team; and
iv. Promotion of local GBTs through professional bodies as well as universities; and
v. Providing tax reduction on green materials and products.

d) The developer's involvement

The developers could be involved in the following way:

i. The dissemination of green building knowledge to developers and users through the provision of the ZIGBAT at a discounted cost; and
ii. Implementation of GB criteria for public buildings, particularly mass housing development through institutions like National Council for Construction (NCC) and National Housing Authority (NHA).

7.2.7 Further research

The following areas must be explored further to generate more evidence:

i. A similar study could be undertaken to include other participants like communities, the local authorities and private investors covering all the ten provinces of Zambia;
ii. The criteria developed in the tool must undergo further validation so that not only professionals are involved but communities and planning authorities; and
iii. Working with regional bodies, more information could be added to the tool so that it encompasses the needs of the member states of COMESA and SADC.

7.2.8 Contribution to the body of knowledge

The purpose of the study was to investigate and improve the corpus of information on a specific subject. This study contributed to the body of knowledge by coming up with a new way of assessing and planning green low-cost houses in Zambia. The is the first attempt to collect information on materials and techniques that can be used to plan green low-cost houses and the information can also be used by researchers and academicians.

a) The research area

The goal of this study was to create an integrated GB assessment tool. The tool was developed using 8 categories to plan or appraise green low-cost housing. This is one of the few studies in Zambia that has looked at green building tool development.

b) Practical use of the study results

The ZIGBAT could be used as a standard for planning and assessing green low-cost housing in Zambia. Building bylaws or housing policies could incorporate the strategies from the tool. For example, 14 different building materials have been incorporated into the tool. ZIGBAT could be used by planners, designers, and builders in integrating GB standards in their projects.

REFERENCES

Abawi, K. (2017) Data Collection methods (Questionnaire & Interview), Training in Sexual and Reproductive Health, Research, Geneva Workshop 2017

Abu Bakar, A.H. and Cheen, K.S. (2013) 'A Framework for Assessing the Sustainable Urban Development', *Procedia - Social and Behavioral Sciences*, 85(2013), pp. 484-492.

Abdelkhalik, H.F., & Azmy,H.H., (2022) 'The role of project management in the success of green building projects: Egypt as a case study', Journal of Engineering and Applied Science, volume 69, Article number: 61 (2022)

Abdelkader O.A. (2020) Impact of perception on "willingness and behavior" of individuals toward switching to sustainable energy practices in buildings. *Energy Reports* 6 pp 2119-2125

Abidin, Z. and Powmya, A. (2014) 'Perceptions on motivating factors and future 510 prospects of green construction in Oman', *Journal of Sustainable*, 7(5), 51, pp. 231-239. Available online at https://core.ac.uk, [accessed 12 April 2016]

Abolore, A.A. (2012) 'Study of Environmental Sustainability in Building Construction in Nigeria and Malaysia', *Journal of Emerging Trends in Economics and Management Sciences*.(ISSN: 2141-7024),(JETEMS) 3(6), pp. 951-961.

Achuo, D.E., Miamo, C.W., Nchofoung, T.N.(2022) Energy consumption and environmental sustainability: What lessons for posterity? *Energy Reports*, Vol. 8, pp.12491-12502

Achola, P.P. and Bless, C.A. (1988) 'Fundamentals of social research methods: an African perspective', Government Printer https://www.sciencedirect.com, [accessed 12 February 2018]

Ade, R. and Rehm, M. (2013) 'Construction cost comparisonccostcomparison between 'green' and conventional office buildings', *Building Research & Information*, 41(2), pp. 199.

Ade, R. and Rehm, M. (2019) The unwritten history of green building rating tools: a personal view from some of the 'founding fathers' *Building Research & Information*, Volume 48, 2020 - Issue 1

Adom, D., Kamil, E., Agyem, J.A.(2018) Theoreticaland Conceptual Framework: Mandatory Ingredients of a Quality Research, *International Journal of Scientific Research*, Volume-7 | Issue-1 | January-2018 | ISSN No 2277 - 8179 | IF : 4.176 | IC Value : 93.98

Agbajor, D.F., and Mewomo, C.M.(2022) 'Green building research in South Africa: A scoping review and future roadmapsEnergy and Built Environment', *Energy and Built Environment*, Available at: https://doi.org/10.1016/j.enbenv.2022.11.001

Agheli, L., and Taghvaee, V.M. (2022) Political stability effect on environment and weak sustainability in Asian countries, Sustainability Analytics and Tooling, Volume 2, 2022, 100007, https://doi.org/10.1016/j.samod.2022.100007

Aghimien, D.O., Aigbavboa, C., Oke, E.A., Musenga,C. (2018) Barriers to Sustainable Construction Practices in the Zambian Construction Industry, Conference: International Conference on Industrial Engineering and Operations ManagementAt: Paris, France, Sustainable Construction

Aghimien, D. O., Adegbemo, T. F., Aghimien, I. E., and Awodele, A. O., (2018) 'Challenges of Sustainable Construction: A Study of Educational Buildings in Nigeria', *International Journal of Built Environment and Sustainability*, Vol.5 No.1, pp. 33-46. Available online at https://doi.org/10.11113/ijbes.v5.n1.244

[accessed 02 March 2016]
Ahn, Y.H., Pearce A.R., Wang Y., and Wang G., (2013)' Factorsand barriers of sustainable design and construction: The perception of green building experience', *International Journal of Sustainable Building Technology and Urban Development*, 4(1), pp. 35-45.
Ahmad, S., Wasim, S., Irfan, S., Gogoi, S. (2019) Qualitative v/s Quantitative Research, Journal of Evidence Based Medicine and Healthcare 6 (43)
Amer, A.L. (2010). "Tooling and Simulation."
Amr, A.I.; Kamel, S.; El Gohary, G.; Hamhaber, J. Water as an Ecological Factor for a Sustainable Campus Landscape. Procedia-Soc. Behav. Sci. 2015, 216, 181–193. [Google Scholar] [CrossRef]
Aongola L., Bass S., Chileshe J. and Daka J. (2009) 'Creating and protecting Zambia ́s wealth: experience and next steps in environmental mainstreaming', *Natural Resources Issues* No.14. IIED. London, UK.
Aje, I. O. (2015) Effective Financing Options for Sustainable Construction in a Developing Economy. A Paper Delivered at a 2-Day National Seminar on Sustainable Construction in a Developing Economy: Factors and Prospects organized by The Nigerian Institute of Quantity Surveyors, Federal University of Technology, Akure Ondo State from Thursday 8th – Friday 9th October.
Akadiri, P.O. (2015) 'Understanding barriers affecting the selection of sustainable materials in building projects', *Journal of Building Engineering*, Vol. 4, December, pp. 86-93. [CrossRef.]
Akanmu, P.W., Nunayon,S.S., Eboson, U.C. (2020) Indoor environmental quality (IEQ) assessment of Nigerian university libraries: A pilot study, Energy and Built Environment
Volume 2, Issue 3, July 2021, Pages 302-314 https://doi.org/10.1016/j.enbenv.2020.07.004
Akinbami, M.O., Oke, S.R., and Bodunrin, M.O.(2021)The state of renewable energy development in South Africa: An overview, *Alexandria Engineering Journal*, Volume 60, Issue 6, December 2021, Pages 5077-5093, https://doi.org/10.1016/j.aej.2021.03.065
Albers. M.(2017) Quantitative Data Analysis, Journal of Technical Writing and Communication, Vol. 47, Issue 2
Almeida, A.P.; Sousa, V.; Silva, C.M. Methodology for estimating energy and water consumption patterns in university buildings: Case study, Federal University of Roraima (UFRR). Heliyon 2021, 7, e08642. [Google Scholar] [CrossRef] [PubMed]
Al-Shetwi, A., (2022) 'Sustainable development of renewable energy integrated power sector: Trends, environmental impacts, and recent challenges, *Science of The Total Environment*, Volume 822
Alabi, A.A. (2012) 'Comparative Study of Environmental Sustainability in Building Construction in Nigeria and Malaysia', *Journal of Emerging Trends in Economics and Management Sciences*, 3 (6), pp. 951-961, 2012.
Alaloul, Musarat, M.A., Babar. M., Rabbani, A. (2022) Assessment of Economic Sustainability in the Construction Sector: Evidence from Three Developed Countries (the USA, China, and the UK), Sustainability 2022, 14(10), 6326; https://doi.org/10.3390/su14106326
Ali A.K., Ahmad M.I., and Yusri Y. (2020) Issues, Impacts, and Mitigations of Carbon Dioxide Emissions in the Building Sector, *Sustainability*, Vol. 12(18). Available at: https://doi.org/10.3390/su12187427

Ali, H.H. and Al Nsairat, S.F. (2009) ‘Developing a green building assessment tool for developing countries – Case of Jordan’, *Building and Environment*, 44(5), pp.1053–1064.

Ali, A.N.A., Jainudin, N.A., Tawie, R. and Jugah, I. (2016) ‘Green initiatives in Kota Kinabalu construction industry’, *Procedia – Social and Behavioral Sciences*, 224, pp. 626-631.

Al horr, Y. Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A., Elsarrag, E. (2016) ‘Impact of Indoor Environmental Quality on Occupant Well-being and Comfort: A Review of the Literature’, *International Journal of Sustainable Built Environment*
Vol. 5(1), pp. 1-11, Available online at: https://doi.org/10.1016/j.ijsbe.2016.03.006

Al Omari, H. and Al Dabbagh, E.L. (2012) ‘Developing a Green Building Assessment Tool for Schools (Case Study in Mosul City)’, *Advanced Materials Research*, 433(440), pp. 5821–5827.

Al-Khatib, I. A., Kontogianni, S., Abu Nabaa, H., Alshami, N., and Al-Sari’, M. I. (2015). Public perception of hazardousness caused by current trends of municipal solid waste management. Waste Management, 36323-330.

Al Khalifa, A.(2019) ‘Adaptation of international sustainability rating tools to Bahrain, A comparative analysis of eleven systems’, International Journal of Architectural Research, https://doi.org/10.1108/ARCH-12-2018-0022

Allen J.G., MacNaughton P., Laurent J.G.C, Flanigan S., Eitland E.S., Spengler J.D. (2015)
‘Green Buildings and Health’, PubMed publication, DOI: 10.1007/s40572-015-0063-y

Alsanad, S.A. (2015) ‘Awareness, Drivers, Actions, and Barriers of Sustainable Construction in Kuwait’, *Procedia Engineering*, volume 118, pp. 969-983, DOI:10.1016/j.proeng.

Alshamrani, O., Galal K., and Alkass S. (2014) ‘Integrated LCA–LEED sustainability assessment Tool for structure and envelope systems of school buildings’, *In Building and Environment*, 80, pp. 61–70. DOI: Available at: https://www.researchgate.net

Almusaed, A., Almssad, A., (2015) Building materials in eco-energy houses from Iraq and Iran, Volume 2, Pages 42-54, https://doi.org/10.1016/j.cscm.2015.02.001

Aliyev, R., Temizkan, H., and Aliyev (2022) Fuzzy Analytic Hierarchy Process-Based Multi-Criteria Decision Making for Universities Ranking. Symmetry 2020, 12(8), 1351; https://doi.org/10.3390/sym12081351

Al-Qawasmi, J., Asif, M., Abd El Fattah, A., and O. Babsail, M. (2019) Water Efficiency and Management in Sustainable Building Rating Systems: Examining Variation in Criteria, Sustainability 2019, 11(8), 2416; https://doi.org/10.3390/su11082416

Amasuomo, T.; Atanda J., Baird G. (2017) ‘Development of a Building Performance Assessment and Design Tool for Residential Buildings in Nigeria’, *In Procedia Engineering* 180, pp. 221–230. DOI: 10.1016/j.proeng.2017.04.181. Available online at https://www.researchgate.net building [accessed 5 April 2016]

Ametepey, O., Aigbavboa, C. and Ansah, K. (2015) ‘Barriers to a successful implementation of sustainable construction in the Ghanaian construction industry’, *Procedia Manufacturing*, Vol. 3, pp.1682-1689.

Ammarapala, V., Chinda,T., Pongsayaporn, P., Ratanachot, W., Koonnamas, P., and (2018) ‘Cross-border shipment route selection utilizing analytic hierarchy process

(AHP) method', *Songklanakarin Journal of Science and Technology* 40(1). March 2018 DOI: 10.14456/sjst-psu.2018.3.
Amir-Behghadami, M., and Sadeghi-Bazarghani, H.(2020) Why and how to apply exploratory sequential mixed methods in health-related psychometric research http://dx.doi.org/10.1136/bmjspcare-2021-003170
Amundsen PA, Evans DW, Rajendran D, Bright P, Bjørkli T, Eldridge S, Buchbinder R, Underwood M, Froud R. (2018) Inclusion and exclusion criteria used in non-specific low back pain trials: a review of randomised controlled trials published between 2006 and 2012. BMC Musculoskelet Disord 2018;19:113.
Anshebo, A.M., Mengesha, W.J., and Sokidoc, L.D. (2022) Developing a Green Building Assessment Tool for Ethiopia, *Heliyon*, 8(9), doi: 10.1016/j.heliyon
Assadiki, R., Merlin, G. Boileau, H., Buhé, C. and Belmir, F. (2022) Status and Prospects of Green Building in the Middle East and North Africa (MENA) Region with a Focus on the Moroccan Context, *Sustainability*, 14, 12594. https://doi.org/
Attaran, S. and Celik, B.G. (2015) 'Students' environmental responsibility and their willingness to pay for green buildings', *International Journal of Sustainability in Higher Education*, Vol. 16 No. 3, pp. 327-340.
Atiyat, D., Matar, A., Abuameereh, S. (2015) The impact of using Green Buildings on the rationalization of consumption of energy resources, water and building materials in the Hashemite Kingdom of Jordan, *European Journal of Environmental and Civil Engineering*
Atsusaka, N. (2003) 'Growing the Green Building Industry in Lane County - a report for the lane county sustainable business and job project, report prepared from the program for Watershed and Community Health', *Institute for a Sustainable Environment*, University of Oregon, USA.
Aspers P., and Ugo Corte, U.(2019) What is Qualitative in Qualitative Research, *Qual Sociol*. 2019; 42(2): 139–160, doi: 10.1007/s11133-019-9413-7
Assefa, S., Lee, H., Shiue, F.J.(2022) 'Sustainability Performance of Green Building Rating Systems (GBRSs) in an Integration Tool', Buildings 2022, 12(2), 208; https://doi.org/10.3390/buildings12020208
Assylbekov, D., Nadeem, A., Hossain, M.A., Akhanova, G. and Khalfan, M. (2021).Factors Influencing Green Building Development in Kazakhstan. *Buildings*, 11(12), p.634. doi:10.3390/buildings11120634.
Aspinall, S., Sertyesilisik, B., Sourani, A. and Tunstall, A. (2012) 'How Accurately Does Breeam Measure Sustainability'? *Scientific Research*, Vol.3, Supplement, 1-8. Available at: http://www.SciRP.org/journal/ce. [accessed 10 May 2018]
Awadh, O. (2017) 'Sustainability and green building rating systems: LEED, BREEAM, Green Star and estidama critical analysis', *Journal of Building Engineering*, 11, pp. 25-29. Available online at http://dx.doi.org/10.1016/j.jobe.2017.03.010 [accessed 20 June, 2018]
Aquino, D.H.M.; Orozco, C.R.; Sy, A.L.C.; Yap, H.K.S. (2013) 'Study on the Relative Importance of Green Building Attributes in the Philippine Urban Setting Using Analytical Hierarchy Process', *Engineering*, Available online: https://www.irbnet.de/daten/iconda/CIB_DC26769.pdf (accessed on 13 April 2019).
Ayarkwa, J. Opoku, J.D., Antwi-Afari, P., Yi Man, R.(2022) 'Sustainable building processes' challenges and strategies: The relative important index approach', Cleaner Engineering and Technology, Volume 7, April 2022, 100455
Aykan, S.(2013) 'Green vs. Sustainable: analysing and expanding LEED (Leadership in energy and environmental design)', New Jersey Institute

Of Technology. Corpus ID: 134244208
Azad, S. and Akbar, Z. (2015) 'The impediments in construction of sustainable buildings in Pakistan', *European Scientific Journal*, No. 29: 11. (CrossRef.)
Avelino, F., Wittmayer, J.M., Pel, B., Weaver, P., Dumitru, Haxeltine, A. Kemp, R., et al. (2019)Technological Forecasting and Social Change, Volume 145, August 2019, Pages 195-206, https://doi.org/10.1016/j.techfore.2017.05.002
Babbie E.R. and Rubin A. (2010) 'Research Methods', 11:1–20. (from publisher). *Social Work Research and Abstracts*, 26(2), pp. 36–36.
Babaei, P., Durukan, I., Güllü, G. (2015) 'Heavy metal concentration of house dust', *International Conference on Civil and Environmental Engineering* (ICOCEE – Cappadocia 2015), Nevsehir, Turkey.
Bahaudin, A.Y., Elias, E.M. and Saifudin, A.M. (2014) 'A Comparison of the Green Building's Criteria', *The 3rd International Building Control Conference* (IBCC) 2013, Kuala Lumpur, November 2013. Kuala Lumpur, Malaysia
Balsalobre-Lorente D., Shahbaz M., Roubaud D., Farhani S., (2018) How economic growth, renewable electricity and natural resources contribute to CO2 emissions? *Energy Policy*, 113 (2018), pp. 356-367.
Banani, R.A., (2011) 'A Sustainable Assessment Method for Non-Residential Buildings in Saudi Arabia : Development of Criteria', A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Architecture) in the University of Leeds.
Bhandari, P. (2020) Descriptive Statistics | Definitions, Types, Examples, Correlational Research, *Scribbr*. Retrieved from https://www.scribbr.com/methodology/correlational-research/
Baker, L. and Phillips, J.(2018) Tensions in the transition: The politics of electricity distribution in South Africa, Volume 37, Issue 1 https://doi.org/10.1177/2399654418778590Banks, J.J.S, Carson, Nelson, B.L. & Nicol D.M. (2004) 'Introduction to Simulation', available online at https://www.pearson.com. [accessed 4 February. 2018].
Barbier E.B, and Burgess J.C (2017) The sustainable development goals and the systems approach to sustainability. Econ Discuss Pap 28:1–24. https://doi.org/10.5018/economics-ejournal.ja.2017-28
Baron, N. and Donath D.,(2016) 'Learning from Ethiopia – A discussion on sustainable building', In Proc. of SBE16 Hamburg International Conference on Sustainable Built Environment Strategies – Stakeholders – Success factors, Held from 7th to 11th March in Hamburg, Germany, 2016.
Barot, P. (2021) Low Cost housing and human behaviour towards low cost housing GLS University
Basten, V., Berawi, M.A, Crévits, I., Latief, Y. (2019b) 'Conceptual development of Cost-benefit analysis based on green building's regional, knowledge, and economic aspects', International Journal of Technology, [online] 10(1), pp. 81–93. Available at: https://scholar.ui.ac.id/en/publications [Accessed 11 May 2020]
Biesta, Gert. (2010). Pragmatism and the philosophical foundations of mixed methods research. In Handbook of Mixed Methods in Social and Behavioral Research, 2nd ed. Edited by Abbas Tashakkori and Charles Teddlie. Thousand Oaks: Sage, pp. 95–117. [Google Scholar]
Belisario,J.M., Jamsek, J., Huckvale, K., O'Donoghue, J., Morrison, C.P. (2015) Comparison of self-administered survey questionnaire responses collected using mobile apps versus other methods, Methodology Review Group, Cochrane

Database Syst Rev. 2015(7): MR000042
Belton, V., and Stewart, T.J., (2001) 'Multiple Criteria Decision Analysis: An Integrated Approach. Kluwer Academic Publishers', Dordrecht.
Benardi, E. Carlucci, S.Cornaro, C. Borhne, R.A.(2018) 'An Analysis of the Most Adopted Rating Systems for Assessing the Environmental Impact of Buildings', *Sustainbility Magazine*. [accessed on 20 August 2017]
Bentley, P.J., Gulbrandsen, M. & Kyvik, S.(2015) The relationship between basic and applied research in universities, Higher Education volume 70, pages689–709 (2015)
Berg, Christian (2020). Sustainable action : overcoming the barriers. Abingdon, Oxon. ISBN 978-0-429-57873-1. OCLC 1124780147.
Berardi, U. (2013) 'Sustainability assessment of urban communities through rating systems', *Environ. Dev. Sustain*. 15, pp. 1573–1591. DOI: 10.1007/s10668-013-9462 [CrossRef]
Berger, P. L., and Luckmann T. (1967) 'Aspects Sociologiques Du Pluralisme', Archives de Sciences Sociales Des Religions, vol. 23, no. 1, 1967, pp. 117–127, 10.3406/assr.1967.2621. Accessed 13 Oct. 2019.
Biermann, Frank; Kanie, Norichika; Kim, Rakhyun E (2017). "Global governance by goal-setting: the novel approach of the UN Sustainable Development Goals". Current Opinion in Environmental Sustainability. Open issue, part II. 26–27: 26–31. doi:10.1016/j.cosust.2017.01.010. ISSN 1877-3435.
Bilbao-U. J. (2013) The limits of human development index: the complementary role of economic and social cohesion, development strategies and sustainability. *Sustainable Develoment*. (2013) 6:400–12. doi: 10.1002/sd.525 (CrossRef)
Borgstede, M., and Scholz, M.(2021) Quantitative and Qualitative Approaches to Generalization and Replication–A Representationalist View, Front. Psychol., Sec. Theoretical and Philosophical Psychology
Volume 12 - 2021 | https://doi.org/10.3389/fpsyg.2021.605191
Bohari, A.A.M., Skitmore, M., Xia, B. and Zhang, X. (2016) 'Insights into the adoption of green construction in Malaysia: the factorsand challenges', *Environment-Behaviour Proceedings Journal*, Vol. 1 No. 4, pp. 45-53. Available online at https://doi.org/10.21834/e-bpj.v1i4.165 [accessed 23 March 2018]
Bond, S. (2010) 'Best of the Best in Green Design: Factorsand Barriers to Sustainable Development in Australia', Lincoln University Digital Dissertation: Canterbury, UK.
Bond, S. (2011) 'Barriers and factorsto green buildings in Australia and New Zealand', *Journal of Property Investment & Finance*, 29(4/5), pp. 494–509. https://www.researchgate.net. [accessed 10 April 2017]
Bond, S. Perrett, G. (2012) 'The key factorsand barriers to the sustainable development of commercial property in New Zealand', *Sustain. Real Estate*, 4, pp. 48–77. Available online at https://www.jstor.org/stable/24860828 [accessed 03 February 2018]
Boone, H., and Boone, D.(2012) Analyzing Likert Data, Economics, The Journal of Extension Corpus ID: 63790806
Boru, T. (2018) Chapter Five Research Design and Methodology 5.1. Introduction, Research Methodology; University of South Africa, PHD Thesis, DOI:10.13140/RG.2.2.21467.62242
Borrego, M., Elliot P Douglas, E.P., and Catherine T Amelink. T.C. (2009) 'Quantitative, Qualitative, and Mixed Research Methods in Engineering Education', online at https://www.onlinelibrary.wiley.com, [accessed 9 February

2018]
Bowick, J. M. (May 2014) ‘Advancing sustainable design with life cycle Assessment’, 2014 article in SAB Magazine.
Bungau, C., Bungau, T., Prada, I.F., Prada, M.F., (2020) ‘Building Design and Construction, Green Buildings as a Necessity for Sustainable Environment Development: Dilemmas and Challenges. *Sustainability*, 14(20), Available at: https://doi.org/10.3390/su142013121
Butt, T.E., Giddings, R.D. and Jones, K.G. (2012) ‘Environmental sustainability and climate change mitigation-CCS technology, better having it than not having it at all’! *Environmental Progress & Sustainable Ener,gy*, 31(4), pp. 642–649.
Bravo G. (2014) The human sustainable development index: new calculations and a first critical analysis. *Ecological indicators* (2014) 37:145–50. doi: 10.1016/j.ecolind.2013.10.020 CrossRef Full Text | Google Scholar
Bukhari, S.A.H. (2011) ‘What is Comparative Study’,Study? *SSRN Electronic Journal*.
Bjørn, A. Owsianiak, M. Laurent, A. Molin, C. Westh, T.B. Hauschild, M.Z.(2013) ‘Mapping and characterization of LCA networks.Int. J. Life Cycle Assess’, 18, pp. 812–827. [CrossRef]
Bouchrika, I. (2022) Type of Research Design: Perspective and Methodological Approaches, *Research*,
Borgstede, M., and Scholz, M. (2021) Quantitative and Qualitative Approaches to Generalization and Replication- a Representationalist View, *Frontiers Psychol*, Vol. 12
Braganca, L. (2007) ‘Improving the quality of existing urban building envelopes: Facades and roofs. Amsterdam’, IOS Press.
BramaBrama, K., Oulhote, Y., Adetoun, M. and Olaniyan, T. (2018) ‘Environmental health research challenges in Africa’, [online] Available at: Insights from symposia organized by the ISEE Africa Chapter at ISES-ISEE 2018 [Accessed Dec. 2019]: December 2019 - 3 (6) - DOI: 10.1097/EE9.0074.
Branker, K. and Pearce J. M. (2010) ‘Financial return for government support of large-scale thin-film solar photovoltaic manufacturing in Canada’, *Energy Policy*, 38(8), pp. 4291–4303.
BREEAM Manual, (2018) ‘SD5078, BREEAM UK New construction’, Available online: http://www.breeam.com [accessed on 26 June 2017].
Brewerton, P.M. and Millward, L.J. (2001) ‘Organisational Research Methods’,
Bruce A., Schick-Makaroff K., Sheilds L., Beuthin R., Molzahn A., Shermak S. (2013).
Lessons learned about art-based approaches for disseminating knowledge. Nurse Researcher, 21, 23–28. doi:10.7748/nr2013.09.21.1.23.e356
Bryant, A. and Charmaz K. (2010) ‘The SAGE Handbook of Grounded Theory Paperback Edition Leeds Beckett University’, UK
Byaro, M., Nkonoki, J., & Mafwolo, G. (2022) Exploring the nexus between natural resource depletion, renewable energy use, and environmental degradation in sub-Saharan Africa, *Environmental Science and Pollution,* Research, volume 30, pages19931–19945 (2023)
Cabalsa, M.O. (2017) ‘Theory of Emotional Strength’, no. 5, pp. 3–5.
Calvert, A. (2021) Ancient Egypt, an introduction, Khan Academy.
Cao, Y., Kamaruzzaman, N.S., and Aziz, N.M. (2022) ‘Green Building Construction: A Systematic Review of BIM Utilization’, Buildings 2022, 12(8), 1205; https://doi.org/10.3390/buildings12081205
Casusale, V. A. & Soneryd, L. (2012) ‘Organizing matters: how ‘the social dimension’

gets lost in sustainability projects', *Sustainable Development* 20(1):18–27.
CASBEE Green Book Live. Available online: http://www.greenbooklive.com [accessed on 26 June 2017].
Castro-Lacouture, D. (2009) 'Optimization Tool for the Selection of Materials using a LEED-based Green Building Rating System in Colombia', *Building and Environment*, 44(6), pp.1162-1170.
Chan, E. H., Qian, Q. K., & Lam, P. T. (2018) 'The market for green building in developed Asian cities and the perspectives of building designers', *Energy Policy*, 37(8), pp. 3061-3070.
Chandratilake, S.R. & Dias, W.P.S. (2013) 'Sustainability rating systems for buildings: Comparisons and correlations', *Energy*, 59, pp. 22–28. Available at: http://linkinghub.elsevier.com [Accessed September 24, 2018]
Chappells, H.; Shove, E., (2005) 'Debating the future of comfort. Environmental sustainability, energy consumption and the indoor environment', *In Building Research & Information* 33 (1), pp. 32–40. DOI: 10.1080/0961321042000322762.
CIB Report Publication 237, Agenda 21 on Sustainable Construction, 1999.
Cilliers, E.J., (2019) Reflecting on Green Infrastructure and Spatial Planning in Africa: The Complexities, Perceptions, and Way Forward, *Sustainbility*, 11(2), 455; https://doi.org/10.3390/su11020455
Chitengi H.S. (2020), 'Providing access to land for low-income groups in sub-Saharan African cities: using a partnership Tool and good governance principles to improve customary land allocation in Lusaka, Zambia', *International Journal of Urban Sustainable Development,* 12 (3), pp. 361.
Clason, D.L. and Dormody, T.J. (1994) 'Analyzing Data Measured by Individual Likert-Type', Items. *Journal of Agricultural Education*, 35, pp 31-35.
Chauhan, M., Patel M., Dave, D., Gupta A. (2019) LOW COST HOUSING, *International Research Journal of Engineering and Technology* (IRJET), Volume: 6 (4) Available online at: www.irjet.net p-ISSN: 2395-0072A
Chehrzad, M., Hosseini, A. & Sardroud. M.J.(2016) 'A review on green building assessment tools: rating, calculation and decision-making, Department of Civil Engineering, Central Tehran Branch, 11th International Conference on Urban Regeneration and Sustainability (SC 2016)
Chiamaka, U., and Aduwo, E.B.(2019) Evaluation of sustainability concepts in public housing
projects in ogun state, nigeria, International Conference on Engineering for Sustainable World Journal of Physics: Conference Series 1378 (2019) 042076, doi:10.1088/1742-6596/1378/4/042076
Chibuye M., (2014) 'Interrogating urban poverty lines–the case of Zambia', *International Institute for Environment and Development*, Vol. 26 (1). Available at: https://doi.org/10.1177/0956247813519047
Chiwele, D., Lamson-Hall, P. and Wani, S. (2022) Cities that Work, UN-HABITAT, Policy Brief, Informal-settlements-in-Lusaka-web.pdf
Coccia, M., & Benati, I.(2018) Comparative Studies, Global Encyclopedia of Public Administration, Public Policy, and Governance Living reference work entry
Cole, L.B. (2019) 'Green building literacy: a framework for advancing green building education', *International Journal of STEM Education*, 6(1).
Cole, Raymond. (2005) 'Building environmental intentions and roles', *Building Research and Information*, 33 (5), pp. 455-467.
Cole, R. J., & Jose Valdebenito, M. (2013) 'The importation of building environmental certification systems: International usages of BREEAM and LEED. Building

Research & Information, 41(6), pp.662-676.
Collinge, W. O.; Thiel, C. L.; Campion, N. A.; Al-Ghamdi, S. G.; Woloschin, C. L.;
Soratana, K. (2015) 'Integrating Life Cycle Assessment with Green Building and Product Rating Systems. North American Perspective', *In Procedia Engineering* 118, pp. 662–669. DOI: 10.1016/j.proeng.2015.08.500. Available online at https://www.sciencedirect.com [accessed 13 February 2016]
Conte, D.O. and Yepes, V. (2012) 'GB: Analysis of State of Knowledge', International *Journal of Construction Engineering and Management*, 1(3), pp. 27-32, DOI: 10.5923/j.ijcem.20120103.03
Cottrell, R.F.(2015) The DGNB as a proto-institution for sustainable certification in Denmark,
Roskilde University, DOI: 10.13140/RG.2.1.1466.7364
Cullen, Howe J. (2010) "Overview of Green Buildings", http://epa.gov/greenbuildings/pubs/GBTstats.
Crankshaw O. and Saladin B. (2019) 'Causes of Urbanisation and Counter-Urbanisation in Zambia: Natural Population Increase or Migration?' *SageJournels*, 56 (10), https://orcid.org/0000-0002-9006-5005
Creswell, J. W., & Clark, V. L. P. (2017). Designing and conducting mixed methods research. Los Angeles: Sage publications. [Google Scholar]
Creswell, J. W. (2015) 'Research Design. Quantative, qualitative and mixed method Approaches', ISBN 978-1-4129-6557-6.
Creswell, John W. (2013). Qualitative Inquiry and Research Design: Choosing among Five Approaches, 3rd ed. Thousand Oaks: Sage. [Google Scholar]
Creswell, John W., and Vicki L. Plano Clark. 2011. Designing and Conducting Mixed Methods Research, 2nd ed. Thousand Oaks: Sage. [Google Scholar]
Crafford, P.L., Blumentritt,M., Wessels, C.B. (2017) The potential of South African timber products to reduce the environmental impact of buildings, S. Afr. J. Sci., 113 (9/10) (2017), p. 8, 10.17159/sajs.2017/20160354
Dahle, M. and Neumayer, E. (2016) 'Barriers to adoption of campus green building', *Smart and Sustainable Buildings*, volume 4 issue 4(ISSN: 2046-6099).
Daniel, W.W (1999) 'Biostatistics: A Foundation for Analysis in the Health Sciences', 7th edition. New York: *John Wiley & Sons*.
DanieL, E. (2016) The Usefulness of Qualitative and Quantitative Approaches and Methods in Researching Problem-Solving Ability in Science Education Curriculum, Journal of Education and Practice www.iiste.org, ISSN 2222-1735 (Paper) ISSN 2222-288X (Online) Vol.7, No.15, 2016
Darko, A.a, Zhang C., Albert P.C. Chan A. (2016) 'Factorsfor GB a review of empirical studies', *Habitat International* 60 (2017).
De Wolf, C., Cordella, M., Dodd, N., Byers, B., and Donatello, S. (2023) Whole life cycle environmental impact assessment of buildings: Developing software tool and database support for the EU framework Level(s), Resources, Conservation and Recycling,Volume 188, January 2023, 106642
Du Plessis, C., & Cole, R. (2011) 'Motivating change: shifting the paradigm', Building Research and Information, 39 (5): 436-449.
Dewilde, C. (2021) 'How housing affects the association between low income and living conditions-deprivation across Europe,' *Socio-Economic Review*, Volume 20, Issue 1, January 2022, Pages 373–400, https://doi.org/10.1093/ser/mwab003
Dempsey, N., Bramley, G., Power, S. and Brown, C. (2011) 'The social dimension of sustainable development: Defining urban social sustainability', *Sustainable Development*, 19(5), pp. 289–300.

De Wolf, C., Cordella, M., Dodd, N., Byers, B., Donatello, S. (2023) Whole life cycle environmental impact assessment of buildings: Developing software tool and database support for the EU framework Level(s) 'Resources, Conservation and Recycling',
Volume 188, January 2023, 106642

DESA-UN. (2018, April 4). The Sustainable Development Goals Report 2017. https://undesa.maps.arcgis.com/apps/MapSeries/index.html (CrossRef.)

Dietler, D., Loss,G., Farnham, A., Hoogh, K., Fink, G., Jürg Utzinger, Winkler, S.M. (2021) 'Housing conditions and respiratory health in children in mining communities: An analysis of data from 27 countries in sub-Saharan Africa', Environmental Impact Assessment Review, Volume 89, July 2021, 106591, https://doi.org/10.1016/j.eiar.2021.106591

Ding, G. K. (2008) 'Sustainable construction—The role of environmental assessment tools', *Journal of Environmental Management*, 86(3), pp. 451-464. Available online at https://doi.org/10.1016/j.jenvman.2006.12.025 [accessed 11 February 2017].

Djokoto, S.D., Dadzie, J. and Ohemeng-Ababio, E. (2014b) 'Barriers to Sustainable Construction in the Ghanaian Construction Industry: Consultants Perspectives', *Journal of Sustainable Development*, 7(1).

Doan, D., Ghaffarianhoseini, A., Naismith, N., Tongrui Zhang, T.(2017) A critical comparison of green building rating systems, Building and Environment 123(Part 1), DOI:10.1016/j.buildenv.2017.07.007

Dobson, H. (2006) 'Mister Sparkle meets the 'Yakuza': depictions of Japan in The Simpsons', *Journal of Popular Culture*, 39(1), pp. 44–68.doi: https://doi.org/10.1111/j.1540-5931.2006.00203

Dodge Data and Analytics (2018), "World green building trends", Smart Market Report, McGraw-Hill International Edition, New York, NY.

Dominick, R. (1988) The Roots of the Green Movement in the United States and West Germany, *Environmental Review*: ER Vol. 12, No. 3 (Autumn, 1988), pp. 1-30

Doorn L.V., Arnold A., & Rapoport E. (2019), In the Age of Cities: The Impact of Urbanisation on House Prices and Affordability. *Journal of Hot Property*, pp.2, Available online at: https://link.springer.com/chapter.

Dovjak, M., & Kukec A. (2019) Health Outcomes Related to Built Environments, *Creating Healthy and Sustainable Buildings*, pp 43–82

Drost, E., A. (2011) 'Validity and reliability in social science research.Education Research and Perspectives', 38 (1), pp. 105-124.

Du, and Duan, H., (2017) 'Green Building Evaluation from a Life-Cycle Perspective in Australia: A Critical Review', *Renewable and Sustainable Energy Reviews* 70 (February 2016). Elsevier, pp. 358–68. Available online at https://doi.org/10.1016/j.rser.2016.11.251.

Du Plessis, C. (2005) 'Action for sustainability: preparing an African plan for sustainable building and construction', *Building Research & Information*, 33(5):405- 415.doi:10.1080/0961321050021897

De Waele, J. D. E. , & Follesa, R. (2003). Human impact on karst: The example of Lusaka (Zambia). International Journal of Speleology, 32(1/4), 71–83. 10.5038/1827-806X.32.1.5 [CrossRef]

Ehrenfeld, J. (2008) 'Sustainability Needs to be Attained, Not Managed. Sustainability: Science, Practice, and *Policy'*, V.4 (2)

Elshafei, G.; Katunský, D.; Zele ˇnáková, M.; Negm, A.(2022) Opportunities for Using Analytical Hierarchy Process in Green Building Optimization. Energies 2022, 15,

4490.
https://doi.org/10.3390/en15124490
El-Husseiny, M.A., El-Setouhy, H. (2022) 'Reviving Low-Tech Modes of Construction as a Method for Sustainability', *Sustainability* 2022, 14(21), 13762; https://doi.org/10.3390/su142113762
Engward, H. (2012) 'Research methodology: a step by step guide for beginners Ranjit Kumar Research methodology: a step by step guide for beginners', Sage. *Nurse Researcher,* 19(3), pp.45–45.
Erridah, A., and Lotfi, B.(2021) The determinants of organizational change management success: Literature review and case study, International Journal of Engineering Business ManagementVolume13,January-December,https://doi.org/10.1177/18479790211016273
Esri Green Infrastructure Magazine, (2012) Available online at https://www.esri.com [accessed 25 June 2016]
Eyewitness. (1996). In *The Oxford Compact English Dictionary*. Oxford, England: Oxford University Press.
FAO (2020) 'Forest area| Sustainable Development Goals| Food and Agriculture Organization of the United Nations". www.fao.org. Archived from the original on 30 December 2020. [accessed 20 February 2022].
Fenner, R. A.; Ryce, T. (2007) 'A comparative analysis of two building rating systems Part 1. Evaluation', *In Proceedings of the Institution of Civil* Engineers - Engineering Sustainability 161 (1), pp. 55–63. DOI: 10.1680/ensu.2008.161.1.55.
Fenner, R. A. and Ryce, T. (2008b) 'A comparative analysis of two building rating systems Part 1. Evaluation', *In Proceedings of the Institution of Civil Engineers - Engineering Sustainability* 161 (1), pp. 55–63. DOI: 10.1680/ensu.2008.161.1.55. Available online at https://www.homepages.ucl.ac.uk. [accessed 25 June 2016].
Fei, W., Opoku, A., Agyekum, K., Anthony, J., Ahmed, V., Chen, C., Lok, K.L. (2021) 'The Critical Role of the Construction Industry in Achieving the Sustainable Development Goals (SDGs): Delivering Projects for the Common GoodSustainability', 2021, 13(16), 9112; https://doi.org/10.3390/su13169112
Ferronato, N. and Torretta V. (2019) 'Waste Mismanagement in Developing Countries: A Review of Global Issues', International Journal of Environmental Research and Public Health, Available online at: https://www.ncbi.nlm.nih.gov/pmc,doi: 10.3390/ijerph16061060.
Fisher, A. C., & Rothkop, M. H. (1989) 'Market failure and energy policy: a rationale for selective conservation', *Energy Policy*, 17(4), pp. 397-406. Available online at http://dx.doi.org/10.1016/0301-4215(89)90010-4.
Fithian, C. and Sheets, A. (2017) 'Green Building Materials: Determining the True Definition of Green', *School of Architecture, University of Texas*, Austin.
Foggia, G.D., (2018) 'Energy Efficiency Measures in Buildings for Achieving Sustainable Development Goals', (4)11, Heliyon Available at: https://doi.org
Forsberg, A., Malmborg, F. V. (2004) 'Tools for environmental assessment of the built environment', *In Building and Environment* 39 (2), pp. 223–228. DOI: 10.1016/j.buildenv.2003.09.004. [accessed 5 February 2017].
Friedrich, E. and Trois, C. (2011) 'Quantification of greenhouse gas emissions from waste management processes for municipalities – A comparative review focusing on Africa. Waste Management', [online] 31(7), pp. 1585–1596. Available at: https://www.deepdyve.com/lp/elsevier/quantification-of-greenhouse-gas-emissions-from-waste-management-vCUrJ896jI [Accessed 25 Jul. 2019].
Frost & Sullivan (2010) 'Market research reports', [online]. Available from:

http://www.frost.com/prod/servlet/frost-home. [Accessed: 11 June 2018].
Fu, Y.,Wang, H., Sun, W., Zhang, X. (2021) 'New Dimension to Green Buildings: Turning Green into Occupant Well-Being', *Buildings* 2021, 11(11), 534; https://doi.org/10.3390/buildings11110534
Galal. S. (2021) Construction sector's value added to GDP in South Africa 2014-2020, Statista publication
Gale, A. (2011) 'A Comparative Study of Environmentally Responsible Design Adoption by architects', *Eastern Michigan University* Digital Commons@EMU(6-15-2011).
Gandhi, R., Pitroda J., and Bhatt B.V. (2017)' Factors Affecting Green Building Based Smart City', *International Journal of Advanced Research in Engineering Science and Technology*. 4(2), pp. 2394-2444.
GBCA(2006) 'Reaching the Stars. Australia: Buildings; Accreditation; Greenhouse effect; Benchmarking; Sustainable development', In Architecture Australia, Vol. 95 (0003-8725), pp. 113–116. Available online at https://www.gbca.org [accessed 20 October 2016].
GBCA, Green star, GBIG (Green Building for Gateway), (2016), available online at http:// new. gbca.org.au/Greenstar.
Geda, A. (2021) The economic and Social Impact of COVID-19 In Zambia, United Nations Conference on Trade and Development, UNCTAD Research Paper No. 79
UNCTAD/SER.RP/2021/22
Geng, Y., Dong, H., Fu, J.B (2012) 'An Overview of Chinese Green Building Standard', *Sustainable Development*, Vol. 20 (3), pp. 211-221.
George, T., and Merkus.J.(2021) Explanatory Research | Definition, Guide, & Examples Revised on January 20, 2023.Scrubbler Publication
Ghazilla, R.A.R., Sakundarini, N., Abdul-Rashid, S.H., Ayub, N.S., Olugu, E.U. and Musa, S.N. (2015) 'Factorsand barriers analysis for green manufacturing practices in Malaysian SMEs: preliminary findings', *Procedia* CIRP, 26, pp. 658-663. (CrossRef.).
Gheyle, N., and Jacobs, T.(2017) Content Analysis: a short overview, Centre for EU Studies, Ghent University, DOI:10.13140/RG.2.2.33689.31841
Gibberd, J. (2005) 'Assessing sustainable buildings in developing countries – the sustainable building assessment tool (SBAT) and the sustainable building lifecycle (SBL)', In the 2005 *World Sustainable Building Conference*, (04-001). available online at http://www.citeseerx.ist.psu.edu [accessed 10 march 2016].
Gibson, Robert B. (2006) 'Sustainability-Based Assessment Criteria and Associated Frameworks for Evaluations and Decisions. Theory, Practice and Implications for the Mackenzie Gas Project Review', *In SSRN Journal*. DOI: 0.2139/ssrn.1663015. Available online at http//www.reviewboard.ca [accessed 30 June 2017].
Gielen, D., Boshell, F., Saygin, D., Bazilian, D.M., Wagner, N., Gorini, R.(2019) 'The role of renewable energy in the global energy transformation', *Energy Strategy Reviews*, Volume 24, April 2019, Pages 38-50
Submit an article Journal homepage.
Gillott, C., Davison, B., & Tingley, D.D. (2022) Drivers, barriers, and enablers: construction
sector views on vertical extensions, *Building Research & Information*, Volume 50, 2022 - Issue 8 Pages 909-923 https://doi.org/10.1080/09613218.2022.2087173

Gordon, G. (2007) 'Tooling and Simulation', McGraw Hill International 2nd Edition
Golove, W.H. and Joseph H. (1996) 'Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency', Energy & Environment Division Lawrence Berkeley *National Laboratory University of California* Berkeley, California 94720
Goforth, C. (2015). Using and Interpreting Cronbach's Alpha, *University of Virginia Library* Research Data Services + Sciences". University of Virginia Library.(CrossRef.).
Gou, Z., Lau, S.S.-Y. and Prasad, D. (2013) 'Market Readiness and Policy Implications for GB: A case study from Hong Kong', Available online at https://doi.org/10.3992/jgb.8.2.162. Available at: *Journal of Green Building* (2013) 8 (2), pp. 162–173. [Accessed 15 Dec. 2020].
Gunbayi, I., and Sorm, S.,(2018) Social Paradigms in Guiding Social Research Design: the Functional, Interpretive, Radical Humanist and Radical Structural Paradigms, International Journal on New Trends in Education and Their Implications, Volume: 9 Issue: 2 ISSN 1309-6249
Graham P.J., and Polizzotto, M.L., (2013) Pit Latrines and Their Impacts on Groundwater Quality: A Systematic Review, *Environ Health Perspect*. 2013 121(5), pp. 521–530. Available at: https://www.ncbi.nlm.nih.gov/pmc
Gray, P.S., Williamson, J.B., Karp, D.A. And Dalphin, J.R. (2012) 15 - Comparative Research Methods, Published online by Cambridge University Press
Grazier, K.L., Trochim, W.M., Dilts, D.M. and Kirk, R. (2013) 'Estimating Return on Investment in Translational Research', *Evaluation & the Health Professions*, [online] 36(4), pp. 478–491. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4084908/.
Green Building Council of Australia (2013) 'The Value of Green Star - A Decade of Environmental Benefits', Melbourne, Australia.
Green Star Council of Australia and Green Star (2015) 'Introduction of the Green Star Rating Tool', https://new.gbca.org [accessed 5 February 2017].
Grey, N.B., Jiang, S., Nascimento, C., Rodgers, S.E., Johnson,R., Lyons, R.A., & Wouter, P.(2017) 'The Short-Term Health and Psychosocial Impacts of Domestic Energy Efficiency Investments in Low-Income Areas: A Controlled Before and After Study', BMC Public Health, 140(17).
Griffiths K, Boyle C and Henning T F P (2020) Infrastructure sustainability rating tools–exploring opportunities for the engineering profession based on international research. Australian Journal of Civil Engineering 18 pp 18 - 28
Goundar, S. (2012) Chapter 3 - Research Methodology and Research Method, Cloud Computing
GRZ, 2010a. National Climate Change Response Strategy. First Draft Sep 2010. Government printers, Available from http://nccrs-zambia.com. Accessed 18/10/10.
GRZ (2020) National Housing Policy, Government printers.
GRZ (2022), DMMU Analytical Report: Volume 5, Census Report, Central Statistical Office (CSO), Lusaka.
GRZ (2017) 7th National Development Plan, Ministry of National Development Planning, Government printers.
GRZ (2010) Zambia Environmental and Climate Change Policy Brief1, Nov. 2010
Haapio, Appu, and Pertti Viitaniemi. (2008) 'A Critical Review of Building Environmental Assessment Tools', *Environmental Impact Assessment Review* 28 (7), pp. 469–82. Available online at https://doi.org/10.1016/j.eiar.2008.01.002.

Habitat for Humanity Report (2021) 'Zambia Capacity Overview', publicinfo@habitat.org

Habitat for Humanity International (2021), "Progress Report: Sustainable Development Goal 11 Target 11.1," https://www.habitat.org/sites/default

Häkkinen, T., & Belloni, K. (2011) 'Barriers and factorsfor sustainable building', *Building Research &Information*, 39(3), pp. 239-255. Available online at http://dx.doi.org/10.1080/09613218.2011.561948.

Halliday, S., (2019) 'Sustainable Construction', 2nd Edition ISBN 9781138200289 Published December 3, 2018 by Routledg 478 Pages.

Halwatura R.U. and Udawattha C. (2017) 'Life cycle cost of different Walling material used for affordable housing in tropics', Case Studies in Construction Materials 7(C)DOI: 10.1016/j.cscm.2017.04.005

Hamedani, A. Z., & Huber, F. (2012) 'A comparative study of DGNB, LEED and BREEAM certificate systems in urban sustainability', *The Sustainable City* VII: Urban Regeneration and Sustainability, 1121 DOI. 10.2495/SC120111[accessed 13 March 2016].

Hussain, A.M., Elyas,T., Nasseef, O.A.(2013) Research Paradigms: A Slippery Slope for
Fresh Researchers, Life Science Journal 2013;10(4)
http://www.lifesciencesite.com

Hafez, F.A., Sa'di, B., Gamal, S., Taufiq-Yap, Y.H., Alrifaey, M., Seyedmahmoudian, M.,
Stojcevski, A Horan, B., Mekhilef, S. (2023) 'Energy Efficiency in Sustainable Buildings: A Systematic Review with Taxonomy, Challenges, Motivations, Methodological Aspects, Recommendations, and Pathways for Future Research' https://doi.org/10.1016/j.esr.2022.101013

Hashemi, S.E, Fazlzadeh, M., Ahmadi, E., Parand M., Ramavandi, B., Taghizadeh, F., Arfaeinia, H. (2020) Occurrence, potential sources, in vitro bioaccessibility and health risk assessment of heavy metal in indoor dust from different microenvironment of Bushehr, Iran. Environ Geochem Health:1–18

Huang, N., Bai, L., Wang, H., Du, Q., Shao, L., and Li, J.(2018) 'Social Network Analysis of Factors Influencing Green Building Development in China', *Int J Environ Res Public Health.* 2018 Dec; 15(12): 2684. doi: 10.3390/ijerph15122684

Hazelrigg, G.A. (1999) 'An Axiomatic Framework for Engineering Design', ASME *Journal of Mechanical Design*, 121: 342-347. http://dx.doi.org/10.1115/1.2829466

Herbert, C., Hermann, A., and McCue, D. (2018) Measuring Housing Affordability: Assessing the 30-Percent of Income Standard, Harvard University Publication.

Heale, R. and Forbes, D. (2013) 'Understanding triangulation in research', *Evidence Based Nursing*, 16(4), pp. 98–98.

Henri, G. (2009) 'Green star rating is it glory or a pain', Submitted in fulfilment of part of the requirements for the Degree of BSc (Hons) (Quantity Surveying), University of Pretoria

Herda, G., Rani, S., Pratibha, R.C., Hazra, S., Gregg, M., Beha, M. and Gupta, R. (2017) 'Sustainable social housing in India: definition, challenges and opportunities', *Technical Report*, Oxford Brookes University, Development Alternatives, The Energy and Resources Institute and UN-Habitat. Oxford. (ISBN: 978-0-9929299-8).

Hertwich, G.E., Ali, S., Ciacci, L., Fishman, T., Heeren, N., Masanet E, Nojavan, F.,

(2019) 'Efficiency Strategies to Reducing Greenhouse Gas Emissions Associated with Buildings, Vehicles, and Electronics—A Review, *Environmental Research Letters*, Volume 14 (4), DOI 10.1088/1748-9326/ab0fe3.

Harelimana, J.B., (2017) 'Towards Affordable Low Cost Housing: Strategies of Low Cost Housing Development for the Low Income Population in Rwanda', Global Journal of Management and Business Research: Vol. 17(6), Online ISSN: 2249-4588 & Print ISSN: 0975-5853

Hickel J. (2019) 'The sustainable development index: measuring the ecological efficiency of human development in the Anthropocene'. *Ecological Economics*. 167:106331. doi: 10.1016/j.ecolecon.2019.05.011

Hill, R., Bowen, P., and Opperman.L. (2015) Sustainable building assessment methods in South Africa: an agenda for research, Fraunhofer IRB, https://www.irbnet.de › iconda › CIB2333

Hilburn, A. M. (2015). Participatory risk mapping of garbage-related issues in a rural Mexican municipality. Geographical Review, 105(1), 41-60.

Hikmat, H. Ali, Saba F. Al Nsairat (2009) 'Developing a green building assessment tool for developing countries – Case of Jordan', *Journal of Building and Environment*, 44(5), pp. 1053-1064.

Hobman, E.V.; Frederiks, E.R. (2014) 'Barriers to green electricity subscription in Australia: love the environment, love renewable energy but why should I pay more'? *Energy Res. Soc. Sci*. 2014, 3, pp. 78–88. (CrossRef).

Huang, N., Bai, L.B, Wang, H.L, Du, Q, Shao, L. Li, J.T. (2018) 'Social network analysis of factors influencing green building development in China', *Int J Environ Res Public Health*. Doi: 10.3390/ijerph15122684. (CrossRef.).

Hu, H., Geertman S., Hooimeijer, P., (2014) 'The willingness to Pay Green Apartments: The Case of Nanjing, China', Urban Studies 51, pp.3459-78.

Huo, X., Yu, A.T.W. and Wu, Z. (2017) 'A comparative analysis of site planning and design among green building rating tools', *Journal of Cleaner Production*, 147, pp. 352–359.

Hwang, B.G.and Tan J.S., (2012) Green building project management: obstacles and solutions for sustainable development. Sustainable Development, 20(5), pp. 335-349.

Illankoon, I.M.C.S., Tam, V.W.Y., Le, K.N., Tran, C.N.N. and Ma, M. (2019) 'Review on Green Building Rating Tools Worldwide: Recommendations for Australia', *journal of civil engineering and management*, 25(8), pp. 831–847.

ILO (2016) 'Good Working Conditions Good Business'? An Analysis of Zamba's Building Construction Market System, Zambia *Green Jobs Publication*.

Liu Tianqi, Lin Chen 2 , Mingyu Yang, Malindu Sandanayake , Pengyun Miao , Yang Shi and Pow-Seng Yap, (2022), Sustainability Considerations of Green Buildings: A Detailed Overview on Current Advancements and Future Considerations: Sustainbility Journal 2022, 14(21), 14393; https://doi.org/10.3390/su142114393 [accessed 10 Feb. March 2022].

Ige, J., Pilkington, P., Orme, J., Williams J.B. (2019) The relationship between buildings and health: a systematic review, Public Health (Oxf). 41(2), pp.121–132: doi: 10.1093/pubmed/fdy138

Isa, K.N., Abdul Samad, Z., and Alias, A. (2014) 'A Review on Sustainability Principles of Building : Formulation of a Theoretical Framework'. Journal of Surveying, *Construction and Property (JSCP)* 5 (1), pp. 1–16. Available online at http://e-journal.um.edu.my/publish/JSCP/[accessed 02 March 2016].

Ishak, A., Asfriyati, Akmaliah, V. (2019) Analytical Hierarchy Process and PROMETHEE as Decision Making Tool: A Review, 1st International Conference on Industrial and Manufacturing Engineering, IOP Conf. Series: Materials Science and Engineering 505 (2019) 012085, *Available at: ISBN 978-92-67-10650-2 ISO Central*

Isaksson A, Linderoth H. 2018. Environmental considerations in the Swedish building and construction industry: The tole of costs, institutional setting and information. J Hous Built Environ. 33(4):615–632.

Jarnehammar, A., Green, J., Kildsgaard, I., Iverfeldt, A., Foldbjerg, P., Hayden, J., & Oja, A. (2008) , Barriers and Possibilities for A More Energy Efficient Construction Sector, *Sustainable Energy Communities in Urban Area in Europe*, Malmö. (CrossRef)

Jeronen K.E. (2020) 'Economic sustainability, Summary', *Encyclopedia of Sustainable Management*, Publisher: Springer, Cham

Jin H, Qian X, Chin T, Zhang H. (2020) Global assessment of sustainable development: based on the modification of human development index with *entropy method. Sustainability*. (2020) 12:1–20. doi: 10.3390/su12083251 (CrossRef)

Juma, S.A., Miraji, M.M. (2018) Environmental Challenges Associated with the Development of Socio-Economic Activities in East African Countries Comparative Study with China, University, College of Engineering, Beijing, China.
DOI: 10.4236/jep.2018.910070

Jones, J., and Smith, J. (2017) Ethnography: challenges and opportunities, Statistics from
Altmetric.com,

Jones SA, Mandyck J. 2016. World green building trends. Smart market
report. New York: Dodge Data and Analytics.Kats, G., Berman A., Perlman J., Alevantis L. and Mills E. (2003) 'The Costs and Financial Benefits of Green Buildings', *A Report to California's Sustainable Building Task Force.* Available online at http//www.greenbuildingcouncil.[accessed 14 July 2017]

Kats, G. (2010) 'Greening Our Built World: Costs, Benefits and Strategies', Washington D.C.: *Island Press*.

Kaunda, D. (2015) 'Low rainfall and crippling power shortages hit Zambia's economy', Thomson Reuters Foundation, Industry, Materials and Utilities.

Karimi, F, Valibeig, N., Memarian, G., and Kamari A. (2022) 'Sustainability Rating Systems for Historic Buildings: A Systematic Review, *Sustainbility*, 14(19), 12448; Available online at https://doi.org/10.3390/su141912448

Kasai, N and Jabbour C. J. (2014) 'Barriers to GB at Two Brazilian Engineering Schools', *International Journal of Sustainable Built Environment* 3(1) pp. 87-95 (CrossRef.).

Kawazu, Y., Shimada, N., Yokoo, N., & Oka, T. (2005) 'Comparison of the assessment results of BREEAM, LEED, GBTool and CASBEE', Paper presented at the *Proc. of I,t. Conf. on the Sustainable Building* (SB05), pp. 1700-1705.

Kaatz, E., et al (2007) 'Broadening project participation through a modified building sustainability assessment', (ISSN: 0961-3218), pp. 1466–4321. Available online at https://www.tandfonline.com [accessed 18 august 2017].

Kaliba, C. (2015) 'knowledge creation, integration and management', a study of civil engineering consulting firms." A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (construction managment) in the University of Zambia.

Kamranfar, S., Azimi, Y., Gheibi, M., Fathollahi-Fard, A.M., Hajiaghaei-Keshteli, M. (2022) Analyzing Green Construction Development Barriers by a Hybrid DecisionMaking Method Based on DEMATEL and the ANP. Buildings 2022, 12, 1641.https://doi.org/10.3390/ buildings12101641
Kasperczyk, N. and Knickel, K. (2004) 'The Analytic Hierarchy Process', *Samantic scholar publication*. Available online https://www.semanticscholar.org/...Kasperczyk-Knickel, [accessed 5 April 2016].
Kennett, S. (2009) 'BREEAM and LEED to Work Together on New Global Standard', *Building UK*, www.building.co.uk. 1-25, (CrossRef.).
Keleş, E.A., Önen, E., and Górecki, J., (2021) 'Determination of Green Building Awareness: A Study in Turkey', *Sustainability* 2022, 14(19), 11943; https://doi.org/10.3390/su141911943
Khan, M.A., Wang, C.C. and Lee, C.L. (2021) 'A Framework for Developing Green Building Rating Tools Based on Pakistan's Local Context. Buildings', 11(5), pp. 202.
Kennedy, H. (2019) 'Sustainable property',Sage articles https://doi.org/10.11772/2378023119836330
Kibert, C.J. (2012) 'Sustainable Construction: Green Building Design', Wiley & Sons, Inc.: New Jersey, NJ, USA.
Kinnunen, K., Saunila, M., Ukko,J., Rantanen, H. (2022), Strategic sustainability in the construction industry: Impacts on sustainability performance and brand *Journal of Cleaner Production*, Vol. 368. Available at: https://doi.org/10.1016
Kivunja, C. and Kuyini A.B. (2017) Understanding and Applying Research Paradigms in Educational Contexts, *International Journal of Higher Education*, Vol. 6, No. 5; 2017, URL: https://doi.org/10.5430/ijhe.v6n5p26
Kuddus, M.A, Tynan, and McBryde, E. (2020) Urbanization: a problem for the rich and the poor? *Public Health Reviews*, 41(1). pp. 1-2. Available at: https://doi.org/10.1186/s40985-019-0116-0
Kshirsagar, B., Mane, V., Saharkar, U., & Salunke, H. (2015) 'Comparative Analysis of Green Building Rating Systems', *International Journal of Engineering Technology, Management and Applied Sciences*, 3 (2).
Komurlu, R., Gurgun, A.P., Arditi, D. (2015) 'Evaluation of LEED Requirements for Site Properties in Developing Country-Specific Certification', Procedia Engineering
Volume 118, 2015, Pages 1169-1176, https://doi.org/10.1016/j.proeng.2015.08.460
Koppa, E.T., Musonda, I., and Zulu, S.L. (2023) Assessment Processes for Infrastructure
Development Projects in Africa, A Systematic Literature Review on Local Sustainability, *Sustainability*, 2023, 15, 1013.https://doi.org/10.3390/su15021013 Green building practitioners' understanding of the concept of sustainability: South African perspective.
Kowet, C.T.M, and Ozumba, O.U.A.(2022) World Building Congress 2022, IOP Conf. Series:
Earth and Environmental Science 1101 (2022) 062027, IOP Publishing, doi:10.1088/1755-1315/1101/6/062027.
Kvale and Steinar. (2008) 'Dominance through Interviews', 12(3), pp. 480-500, *Sage Publications* Available online at https://doi.org [accessed 20 February 2018].
Labaran, Y.H., Mathur V.S., Farouq M.M., (2021) The Carbon Footprint of

Construction Industry: A Review of Direct and Indirect Emission, *Journal of Sustainable Construction Materials and Technologies,* Vol. 6 (3), pp. 101–115.
Lam, P.T., Chan, E.H., Ann, T.W., Cam, W.C., Jack, S.Y., (2015) 'Applicability of clean development mechanism to the Hong Kong building sector', J. *Clean. Production*. 109, pp. 271-283.
Lamb, W.F., Wiedmann, T., Pongratz, J., Andrew, R., Crippa, M., Olivier, J.G., Wiedenhofer, D., Mattioli, G., Khourdajie, A., House, J. (2021) A review of trends and factorsof greenhouse gas emissions by sector from 1990 to 2018, *Environmental Research Letters*, Volume 16, Number 7. DOI 10.1088/1748-9326/abee4e
Lapworth, D.J., Stuart, M.E., Pedley, S. D. Nkhuwa, C.W., Tijani M. N. (2018) A review of urban groundwater use and water quality challenges in Sub-Saharan Africa. Groundwater Report
Luangcharoenrat, C. and Intrachooto, S. (2018) 'Comparative Analysis of Green Building Rating Standards for Improvement Opportunities', *Periodica Polytechnical Architecture*, 50(1), pp. 41– 49.
Leedy P. and Ormrod J. (2010) 'Practical Research - Planning & Design', Edition/Format: Print book: English: 9th ed. *Publisher: Upper Saddle River, NJ*: Available online at http//www.worldcat.org, [accessed 10 December 2017].
LEED Rating System (2018) 'U.S Green Building Council', Available online at https://www.usgbc.org/tools/leed-certification/ fees [accessed 10 August 2017].
Lee, S., Lee, B., Kim, J. and Kim, J. (2013) 'A Financing Tool to Solve Financial Barriers for Implementing Green Building Projects', *The Scientific World Journal*, 2013, pp.1–10.
Leung, L.(2015) Validity, reliability, and generalizability in qualitative research, Family Med Prim Care. 2015 Jul-Sep; 4(3): 324–327. doi: 10.4103/2249-4863.1613061,2
Li X.X, Liu Y.M, Song T. Calculation of the green development index. *Social Science*, China. (2014) 6:69–95.
Lienhardt C, Glaziou P, Uplekar M, Lönnroth K, Getahun H, Raviglione M. (2012) Global tuberculosis control: lessons learnt and future prospects. Nat Rev Microbiol.;10(6):407–16. https://doi.org/10.1038/nrmicro2797.
Lorenz, D., Lützkendorf, T. & Panek, A. (2005) 'Sustainable construction in Central/ Eastern Europe: implications from SB04 in Warsaw', *Building Research &Information*, 33(5), pp. 416-427. Available online at https://www https://doi.org/10.1155/2013/240394
Liu, X. and Hu, W. (2019) 'Attention and sentiment of Chinese public toward green buildings based on Sina Weibo', *Sustainable Cities and Society*, 44, pp. 550–558.
Liu, T., Chen L.,Yang, M., Sandanayake, M., Miao, P., Shi, Y., and Yap, P.S. (2022) 'Sustainability Considerations of Green Buildings: A Detailed Overview on Current Advancements and Future Considerations', *Sustainability*, (14), 14393. https://doi.org10.3390/su142114393
Lu, W., Chen, X., Peng, Z.U. (2018) 'The effects of green building on construction waste minimization: Triangulating 'big data' with 'thick data', *Waste Management* 79(2018):142-152, DOI:10.1016/j.wasman.2018.07.030
Lusaka City Council and Environmental council of Zambia (2003) 'Lusaka City State of Environment Outlook Report', (ISBN 978-9982-861-01-4).
Marchi, L., Antonini, E., and Politi, S. (2021) Green Building Rating Systems (GBRSs) *Encyclopedia*, 1(4), 998-1009; https://doi.org/10.3390/encyclopedia1040076
Makasa, P. (2010) The 1996 Zambia National Housing Policy, Sustainable Housing

Areas 31, IOS Press under the imprint Delft University Press
Malanca, M. (2010) ‘Conference on Promoting Green Building Rating in Africa United Nations Human Settlements Programme (UN-HABITAT)’, *Urban Environment and Planning Branch. UNON, Nairobi.*
Mangialardo, A.; Micelli, E.; Saccani, F. (2019) ‘Does Sustainability Affect Real Estate Market Values? Empirical Evidence from the Office Buildings Market in Milan (Italy),’ *Sustainability 2019,* 11, 12. [CrossRef].
McArthur J., Herrera H., Mantha P. (2014) ‘International Sustainability Systems Komparsin Key International Sustainability Systems: Energy and Water Conservation Requirements’, CoreNet Global by Ove Arup & Partners Ltd. pp. 3-10 Available online at,https://spectrum.library.concordia.ca/982747.
McCombes S. (2019) Descriptive Research Definition, Type, Method and Examples (2022) Scribbr
McGraw Hill Construction (2004) ‘Smart Market Report: Business Value of BIM for Construction in Major Global Markets How Contractors around the World Are Driving Innovation with Building Information Tooling’, Available online at https://www.icn-solutions.
Machingura, Fortunate (2017). "The Sustainable Development Goals and their trade-offs". ODI: Think change. [CrossRef].
Marilyn K. S., and Goes J. (2011) ‘Correlational Research’, In Dissertation and Scholarly and resources. Available online at http//www.dissertationrecipes.com. [accessed February 2018].
Marshall, C. and Rossman G.B. (1995) ‘Designing Qualitative Research’, Thousand Oaks, CA: Sage.
Marion, R. and Uhl-Bien, M. (2008) ‘Complexity Theory and Al-Qaeda: Examining Complex Leadership. Emergence’, 5(1), pp.54–76.
Markelj, J.; Manja K., Petra G., Martina Z.S. (2014) ‘A Simplified Method for Evaluating Building Sustainability in the Early Design Phase for Architects’, *In Sustainability* 6 (12), pp. 8775–8795. DOI: 10.3390/su6128775. Available online at https://www.ideas.repec.org.
Matisoff, D.C., Noonan, D.S., Mallory, E. F. (2016) ‘Green Buildings: Economics and Policies’, Review of Environmental Economics and PolicyVolume 10, Issue 2Summer 2016, pp. 183-367
Mattoni,B., Asdrubali, F., Baldinelli, G., Bianchi, F., Bisegna, F., Evangelisti, L., Gori, P., Grazieschi, G., Cusano, N., Guattari, C. (2019) Comparison Among Different Green Buildings Assessment Tools: Application to a Case Study, Semantic Scholar Corpus ID: 197616390
Mayhoub, M.G., Sayad, Z.M.T., Ali, A.M., Ibrahim G.M., (2021) ‘Assessment of Green Building Materials’ Attributes to Achieve Sustainable Building Façades Using AHP’,
Buildings, 11(10), 474; https://doi.org/10.3390/buildings11100474
Mendes, A., Pereira, C., Mendes, D., Aguiar, L., Neves, P., Silva, S., Batterman, S. and Teixeira, J.P. (2013) ‘Indoor Air Quality and Thermal Comfort—Results of a Pilot Study in Elderly Care Centers in Portugal’, *Journal of Toxicology and Environmental Health,* Part A, 76(4-5), pp. 333–344.
Meena, C.S., Kumar, A., Jain, S., Rehman, A., Mishra, S., Sharma, N.K., Bajaj, M., Shafiq M., Eldin, E.T. (2022) ‘Innovation in Green Building Sector for Sustainable Future’, Energies, (15) 6631, https://doi.org/10.3390/en1518663
Mensah, J.,(2019) Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review, *Cogent Social Sciences*,Volume

5, 2019 - Issue 1
McLeod, S. (2014) ‘Likert Scale’, Simplypsychology.org. Retrieved:http://www.simplypsychology.org /Likert-scale.html/pdf.
Middleton, F. (2022) The 4 Types of Validity in Research | Definitions & Examples, Scribber Publication.
Mill, J.S. (2008) ‘A System of Logic: Ratiocinative and Inductive’, 1843 1, pp.1–627. https://doi.org/10.1037/11967-000.
Moghayedi A., Awuzie B., Omotayo T. ,Karen Le Jeune K.L., Massyn M., Christiana C.E., Braune M., and Byron P.4A Critical Success Factor Framework for Implementing Sustainable Innovative and Affordable Housing: A Systematic Review and Bibliometric Analysis
Mohammed, M. (2016) ‘Emerging trends in construction organisational practices and project management knowledge area’, In 9th cidb Postgraduate Conference. School of Construction Economics and Management, Faculty of Engineering and Built Environment. openbooks.uct.ac.za [accessed 0ctober 2017].
Mohd Isa, N.K., Abdul Samad, Z. and Alias, A. (2014) ‘A Review on Sustainability Principles of Building: Formulation of a Theoretical Framework’, *Journal of Surveying, Construction & Property*, 5(1), pp.1–16.
Møller, R.S., Rhodes, M.K., and & Larsen, T.S.(2018) Sustainability Tool for Assessment, Planning, Learning, and Engaging, Energy Prod. & Mgmt., Vol. 3, No. 1 (2018) DGNB Building Certification Companion:
Mosly, I. (2015) ‘Barriers to the Diffusion and Adoption of Green Buildings in Saudi Arabia’, *Journal of Management and Sustainability*, 5(4), pp.104. Available online at http://dx.doi.org/10.5539/jms.v5n4p104.
Morgan, D.L. (1998) ‘Practical Strategies for Combining Qualitative and Quantitative Methods: Applications to Health Research’, *Qualitative Health Research*, 8(3), pp. 362–376.
Morgan, David L. (2014a). Integrating Qualitative and Quantitative Methods: A Pragmatic Approach. Thousand Oaks: Sage. [Google Scholar]
Morse, J.M. (1991) ‘Evaluating Qualitative Research’, Qualitative Health Research, *Sage Journals*, 1(3), pp. 283–286. https://doi.org/10.1177/104973239100100301
Moustakas C.N. (1994) ‘Phenomenological Research Methods’, 150.192 20, British Library D S C 94/20840. 1994.
Mwiya B. (2015) ‘An analysis of unit rates for roadworks in zambia incorporating neural network’, A dissertation submitted in partial fulfillment of the requirements for the degree *of* Doctor of Philosophy (construction managment) in the University of Zambia.
Ministry of Finance (2019) ‘Zambia: Budget 2020’, Africa Research Bulletin: Economic, Financial and Technical Series, Government printers 55(10), pp.22325B-22326B.
Ministry of Local Government and Housing (MLGH). (2016) ‘Sustainable Housing Guidelines (SHG)’, Lusaka: Government printers.
Ministry for the Environment, Natural Conservation and Nuclear Safety (MENCNS). (2009) ‘Sustainable Building Construction in Africa, Overview of SBC in Africa practical insights and illustrative examples’.
Miller, J.C., Smith, N.S., Pugatch, M.(2020) Experimental and quasi-experimental designs in implementation research, Psychiatry Research Volume 283, January 2020, 112452, https://doi.org/10.1016/j.psychres.2019.06.027
Miyazaki, G., Kawakubo, S., Murakami, S., and Ikaga, T.(2019) How can CASBEE

contribute as a sustainability assessment tool to achieve the SDGs? IOP Conference Series: Earth and Environmental Science, Volume 294, Sustainable Built Environment Conference 2019 Tokyo (SBE19Tokyo)

Mpakati-Gama E.C., Wamuziri S., Sloan B.(2012) 'Green building challenges: Evaluating the operation of adopted building assessment tools', - Case study, School of Engineering and the Built Environment, Edinburgh Napier University, 10 Colinton Road, EH10 5DT United Kingdom.

Ministry of Housing and Infrastructure development (2020) 'National Housing Policy 2020-2024: Affordable and Decent Housing by 2030'.

Mrkonjić, E. (2021) Green Building Statistics: Important Step Towards Sustainability, *Seed Scientific*, Science Jobs, Available at: https://seedscientific.com/environment/green-building-statistics

Mudenda, P.K., Makashini, L., Malama, A., Abanda H. (2018) 'Review of Renewable Energy Technologies in Zambian Households: Capacities and Barriers Affecting Successful Deployment', Buildings, 8(6), 77; https://doi.org/10.3390/buildings8060077

Muijs, D., (2011) 'Leadership and organisational performance: from research to perception', *International Journal of Education and Management. Emerald publication*: Vol. 25 No. 1, pp. 45-60. available online at: n at: https://www.researchgate.net/publication/319128421 [accessed 10 December 2021].

Munshifwa, E.K., Mwenya, C.M. and Mushinge, A. (2021) 'Urban Development, Land Use Changes and Environmental Impacts in Zambia's Major Cities: A Case Study of Ndola', *Sustainable Real Estate in the Developing*: ISBN: 978-1-83867- 838-8 World. [online] Available at: https://doi.org/10.1108/978-1-83867-837-5[accessed on 10 October, 2021].

Murray, A.; Skene, K.; Haynes, K. (2017) The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. J. Bus. Ethics, 140, 369–380.

Museteka, L. , & Bäumle, R. (2009). Development of a groundwater information & management program for the Lusaka groundwater systems. Federal Ministry for Economic Cooperation and Development (Vol.1). Retrieved from https://www.bgr.bund.de/EN/Themen/Wasser/Projekte/abgeschlossen/TZ/Zambia

Mushi, F., Nguluma, M.N., Kihila, J.(2022) 'Critical review of African green building research', *Building Research and Information* 50(4):1-18, DOI:10.1080/09613218.2021.2015276

Nadzirah, Z.and Carmen T., Yee M. (2015) 'An Insight of Sustainable Development-A Study among Construction Professional in Malaysia', *International Journal of Current Research and Academic Review*, January-201, pp. 56-64.

Nahiduzaman, K.; Al-Dosary, A.; Abdallah, A.; Asif, M.; Kua, H.; Alqadhib, A. Change-agents driven interventions for energy conservation at the Saudi households: Lessons learnt. J. Clean. Prod. 2018, 185, 998–1014. [Google Scholar] [CrossRef]

Nair, D.G., Enserink, B., Gopikuttan, G., Vergragt, P. Fraaij, A.Dalmeijer, R. (2005), A Conceptual Framework for Sustainable – Affordable Housing for the Rural Poor in less Developed Economies, The 2005 World Sustainable Building Conference, Tokyo, 27-29 September 2005 (SB05Tokyo)

Nasereddin, M., Price A., (2021) 'Addressing the capital cost barrier to sustainable construction', *Developments in the Built Environment*, Vol. 7, July 2021, 100049

Nassar, D.M., Elsayed, G.E.(2018) 'From Informal Settlements to sustainable communities', *Alexandria Engineering* Journal, Volume 57, Issue 4, December 2018, Pages 2367-2376

Volume 2, Issue 4, April– 2017 International Journal of Innovative Science and Research Technology

Nasser, A., Ashraf, A., Salim, D.K., Gayathri, P., Vishnu, N.(2017) Comparative Study of Conventional and Green Residential Building, Project Report 2017, ISSN No: - 2456 – 2165

Nasr, E. and Alaa El-eashy, A. (2022) Features of Sustainability in the Egyptian Architecture, MEL. Mansoura Engineering Journal, Architectural Department., Faculty of Engineering., El-Mansoura university., Mansoura., Egypt.10.21608/BFEMU.2020.124897

Neubauer, B.E., Witkop, C.T., Varpio, L.(2019) How phenomenology can help us learn from the experiences of others, *Perspect Med Educ*. 2019 Apr; 8(2): 90–97. doi: 10.1007/s40037-019-0509-2

Nguyen, Binh K.; Altan, Hasim (2011) 'Comparative Review of Five Sustainable Rating Systems', *In Procedia Engineering* 21, pp. 376–386. DOI: 10.1016/j.proeng.2011.11.2029. Available online at https://www.sciencedirect.com [accessed 13 October 2016].

Nguyen, H.D., & Macchion, L.(2022) Risk management in green building: a review of the
current state of research and future directions, Environment, Development and Sustainability volume 25, pages2136–2172.

Ntshwane, K., Essah, E. and Dixon, T. (2014) 'Investigating the level of awareness of building assessment tools in the construction industry of Botswana', Annual ARCOM Conference, Portsmouth, U.K.

Niekerk, V.A.J.(2020) Inclusive Economic Sustainability: SDGs and Global Inequality, *Sustainability* 2020, 12(13), 5427; https://doi.org/10.3390/su12135427

Nikyema, G.A., and V Y Blouin, V.Y. (2020) 'Barriers to the adoption of green building materials and technologies in developing countries: The case of Burkina Faso January 2020IOP Conference Series Earth and Environmental Science 410(1):012079 DOI:10.1088/1755-1315/410/1/012079

Nowell S.L., Norris, M.J. and Moules, N.J.(2017) Thematic Analysis: Striving to Meet the Trustworthiness Criteria, International Journal of Qualitative Methods https://doi.org/10.1177/1609406917733847

Nyoni, J.K., Maronga, A., Tuohy G.P., Shane A. (2021) 'Hydro–Connected Floating PV Renewable Energy System and Onshore Wind Potential in Zambia', Energies, 14(17), 5330; https://doi.org/10.3390/en14175330.

Obahoundje, S., Diedhiou, A., Kouassi L.K., Youan, M., Mortey, E.M., Roudier, P., and Kouame, D.G.K. (2022), Analysis of hydroclimatic trends and variability and their impacts on hydropower generation in two river basins in Côte d'Ivoire (West Africa) during 1981–2017, Environmental Research Communications, Volume 4, Number 6, DOI 10.1088/2515-7620/ac71fa

Odysseus, M.; Ioannis, T.; Alexandra, N. (2006) 'Sustainable construction and factorsof change in Greece: A Delphi study', *Constr. Manag. Econ*. 24, pp. 113–120.

Ofori, G. (2006) 'Revaluing Construction in Developing Countries: A research Agenda', *Journal of Construction in Developing Countries*:11.

Oguntona, O.A., Akinradewo, O.I., Ramorwalo, D.L., Aigbavboa, C.O. and Thwala, W.D. (2019) 'Benefits and Factorsof Implementing Green Building Projects in

South Africa', *Journal of Physics*: Conference Series, 1378: 032038.

Ogunsanmi, O. (2013) 'Effects of Procurement Related Factors on Construction Project Performance in Nigeria', *Ethiopian Journal of Environmental Studies and Management*, 6(2), pp. 12.

Oke, A., Aghimien, D., Aigbavboa, C. and Musenga, C. (2019) 'Factorsof Sustainable Construction Practices in the Zambian Construction Industry', *Energy Procedia*, 158, pp. 3246–3252.

Okoro, C. S, Musonda I., and Agumba J. (2016) Identifying Barriers to Urban Residential Infrastructure Development: A Literature Review. *School of Civil Engineering and the Built Environment*, South Africa

Oluwagbamila, E., Polycarp, U.S., Kasimu, S.(2019) Facts and Fiction in Positivism and Neo Positivism, Research on Humanities and Social Sciences www.iiste.org ISSN 2224-5766 (Paper) ISSN 2225-0484 (Online) DOI: 10.7176/RHSS

Vol.9, No.4, 2019 21Onososen, A.O., Osanyin, O. and Adyemo, M. 0. (2019) 'Factorsand Barriers to the Implementation of Green Building Development', *PM World Journal*, Vol. VIII, Issue IX – October 2019.

Owen, C. (2006) 'Reaching the stars. Australia: Buildings; Accreditation; Greenhouse effect; Benchmarking; Sustainable development', Green Building Council of Australia;. *In Architecture Australia*, Vol. 95 (0003-8725), pp. 113–116. Available online at https://www.gbca.org [accessed 20 October 2016]

Owensby-Conte, D. and Yepes, V. (2012) 'Green Buildings: analysis of state of knowledge', *International Journal of Construction Engineering and Management* 2012; 1(3), pp. 27-32. doi: 10.5923/j.ijcem.20120103.03. .

Oslon and Kellum, (2003) 'The Impact of Sustainable Buildings on Educational Achievements in K-12 Schools', Leonardo Academy Inc., Wisconsin USA. pp.7-9 Available online at www.cleanerandgreener.org. [accessed 13 October 2017].

Oswaldo, L., Akbari H., Bertoldi P., Luisa F., Eyre N., (2014) 'Buildings', Cambridge Press, Cambridge, United Kingdom and New York, NY, USA.

Oyalowo, B. (2016) 'Barriers and Factorsof sustainable building construction and management in Lagos metropolis, Nigeria', Conference: CIB Conference, Lagos, Nigeria Available online at https://www.researchgate.net/publication/309177646.

Oyedokun, B.T. (2017) 'Green premium as a factor of green-labelled commercial buildings in the developing countries: Lessons from the UK and US', *International Journal of Sustainable Built Environment*, Volume 6, Issue 2, December 2017, Pages 723-733

Palich, N. and Edmonds, A.(2013) 'Social sustainability: creating places and participatory processes that perform well for people', Environment Design Guide, EDG 78 NP: (November 2013), pp. 1-13 (13 pages)

Park, Y.S., Konge, L., Anthony R. Artino, A.R.(2020) The Positivism Paradigm of Research.

journal of the Association of American Medical Colleges, 95 (5). http://dx.doi.org/10.1097/

Parveen,H. and Showkat, N.(2017), Validity, Reliability, Generalizability, Paper: Critérios de inclusão e exclusão em estudos de pesquisa: definições e por que eles importam

Patino, C.M., and Ferreira, C.J. (2018) 'Inclusion and exclusion criteria in research studies: definitions and why they matter', *Bras Pneumol* v.44(2), doi: 10.1590/S1806-37562018000000088

Persson, J. and Gronkvist, S. (2014) Factorsfor and barriers to low-energy buildings in Sweden', *Journal of Cleaner Production*, Vol. 109: 296-304. (CrossRef.)

Peter L.L. and Yang Y. (2019) Urban planning historical review of master plans and the way towards a sustainable city: Dar es Salaam, Tanzania. *Frontiers of Architectural Research.* Vol 8(3), pp. 359-377 Available at: https://doi.org/10.1016/j.foar.2019.01.008

Pickvance, C. (2005) 'The four varieties of comparative analysis: the case of environmental regulation', *Journal of Housing and the Built Environment*, 16, pp. 7-28.

Pheng, L.S., and Grönkvist, S. (2019) 'The Economy and the Construction Industry', Nature Public Health Emergenc, 2019 : 21–54, doi: 10.1007/978-981-13-5847-0_2

Phiri (2016) 'Challenges of Affordable Housing Delivery in Zambia. Centre for Affordable Housing Finance in Africa. Available at: https://housingfinanceafrica.org/documents/challenges-of-affordable-housing-delivery-in-zambia/

Pococka, J., Stecklerb, C. and Hanzalova, B.(2016) Improving Socially Sustainable Design and
Construction in Developing Countries, *Procedia Engineering* 145 (2016) 288 – 295

Pons, O., and Aguado A. (2012) 'Integrated value Tool for sustainable assessment applied to technologies used to build schools in Catalonia, Spain', *In Building and Environment* 53, pp.49–58. DOI: 10.1016/j.buildenv.2012.01.007. Available online at https://upcommons.upc.edu.[accessed 20 October 2016].

Penna A.N. (2022) SDG 7 – A History of Fossil Fuel Consumption and Its Replacement with Renewable Sources of Energy Get access Arrow, Pages 210–240. https://doi.org/10.1093/oso/9780192848758.003.0008

Penela, C., Mantecon.I.M, Alvarez.S. and Castroman.J.L. (2017) 'Role of Green Collaborative Strategies in Improving Environmental Sustainability in Supply Chains', Insights from a Case Study. *Business Strategy and the Environment*, 27(6), pp. 728–741.

Pham, D.H., Kim, B., Lee, J. and Ahn, Y. (2020) 'An Investigation of the Selection of LEED Version 4 Credits for Sustainable Building Projects', *Applied Sciences*, 10 (20), pp. 7081.

Pitroda, J. and Bhatt, B.V. (2017) 'Factors Affecting Green Building Based Smart City. International Journal of Advance Research in Engineering, Science & Technology', ISSN: 2393-9877, p-ISSN: 2394-2444.

Purvis, Ben; Mao, Yong; Robinson, Darren (2019). "Three pillars of sustainability: in search of conceptual origins". Sustainability Science. 14 (3): 681–695. doi:10.1007/s11625-018-0627-5. ISSN 1862-4065. CC BY icon.svg Text was copied from this source, which is available under a Creative Commons Attribution 4.0 International License

Ratner B. Variable selection methods in regression: Ignorable problem, outing notable solution. Journal of Targeting, Measurement and Analysis for Marketing 2010;18:65–75. 10.1057/jt.2009.26 [CrossRef] [Google Scholar]

Qian, Q. K., & Chan, E. H. (2010) 'Government measures needed to promote building energy efficiency (BEE) in China', *Facilities*, 28(11/12), pp. 564-589.

Rajalakshmi, S., (2016) 'Sustainable development through environmental ethics International Journal for Applied Research, 2 (2016), pp. 464-467

Ragheb A., El-Shimy H., Ragheb G. (2019) 'Green Architecture: A Concept of Sustainability', Procedia - Social and Behavioral Sciences, Vol. 216, pp. 778-787.

Ragheb, A.F. (2011) 'Towards Environmental Profiling for Office Buildings Using

Life Cycle Assessment (LCA)', A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Architecture) in the University of Michigan.
Republic of Zambia (2011). Sixth national development plan 2011–2015. Ministry of Finance and National Planning.
Reed, R., Bilos, A., Wilkinson, S., & Schulte, K. (2009) 'International comparison of sustainable rating tools'. The Journal of Sustainable Real Estate, 1(1), pp. 1-22.
Rehm, M. and Ade, R. (2013) 'Construction costs comparison between 'green' and conventional office buildings', *Building Research & Information*, 41(2), pp. 199.
Ramanathan, R., (2001) 'A note on the use of the analytic hierarchy process for environmental impact assessment', *Journal of Environmental Management*, 63, pp. 27−35.
Reed, R., Bilos, A., Wilkinson, S., & Schulte, K. (2009)' International comparison of sustainable rating tools', *The Journal of Sustainable Real Estate*, 1(1), pp.1-22.
Reed, R., Wilkinson S., Bilos A., and Schulte K.W. (2011) 'A Comparison of International Sustainable Building Tools – An Update', The 17 Th Annual Pacific-Rim Real Estate Society Conference, Gold Coast, pp. 16-19 January 2011.
Retzlaff, R. C. (2008) 'Green Building Assessment Systems: A Framework and Comparison for Planners", *Journal of the American Planning Association* 74 (4), pp. 505–19. Available online at https://doi.org/10.1080/01944360802380290.
Richardson, G., & Lynes, J. (2007) 'Institutional motivations and barriers to the construction of green buildings on campus: A case study of the University of Waterloo, Ontario', *International Journal of Sustainability in Higher Education*, 8(3), pp. 339-354. Available online at http://dx.doi.org/10.1108/14676370710817183 [accessed 02 February 2020].
Richard, R.,Wilkinson, S., Bilos A., and Karl-Werner Schulte, K.S., (2011) 'A Comparison of International Sustainable Building Tools – An Update', The 17 Th Annual Pacific Rim Real Estate Society Conference, Gold Coast 16-19 January 2011. richard.reed@deakin.edu.au [accessed on 08 June, 2018].
Rivera, A. (2009) 'International applications of building certification methods: A comparison of BREEAM and LEED'.
Rlandson, et al., (1993) 'Observation Methods.pdf', Newbury Park, CA Sage Publications.
Roderick, Y., McEwan, D., Wheatley, C., & Alonso, C. (2009) 'Comparison of energy performance assessment between LEED, BREEAM and green star', Paper presented at the Eleventh International IBPSA Conference, 27-30.
Rodrigue, J.P., (2020) Urban Transport Challenges, The Geography of Transport Systems, Fifth Edition, New York: Routledge, 456 pages. ISBN 978-0-367-36463-2, doi.org/10.4324/9780429346323
Rocha, J., Oliveira, S., Viana, M.C., Ribeiro, A.I. (2022) 'Climate change and its impacts on health, environment and economy', Integrated Approach to 21st Century Challenges to Health, Pages 253-279, https://doi.org/10.1016/B978-0-12-822794-7.00009-5
Rouse, D. (2016) 'A new conceptual Tool of influences driving sustainability based on case evidence of the integration of corporate sustainability management control and reporting', *Journal of cleaner production*, [online] Vol.136 Part A: 78-85. Available at: https://www.sciencedirect.com/science/article [Accessed 10 Nov. 2016].
Roll-hansen, N. (2009) '[Why the Distinction between Basic (Theoretical) and Applied (Practical)" Centre for the Philosophy of Natural and Social Science Contingency

and Dissent in Science', available online at https://pdfs.semanticscholar.org, [accessed 22 February 2018].

Sabiu, M. and Tadesse, F.H. (2020) 'Factorsand Barriers of Sustainable GB in Kano State, Nigeria', Available online at https://www.researchgate.net/publication/341984763. 29(11), (2020), pp. 634-640.

Sabbagh, M.J., Mansour, O.E., Banawi, Sadeghi, M., Naghedi, R., Behzadia, K., Shamshirgaran, A., Tabrizi, M.R., Maknoon, R.(2022) 'Customisation of green buildings assessment tools based on climatic zoning and experts judgement using K-means clustering and fuzzy AHP', *Building and Environment*, Volume 223, September 2022, 109473, https://doi.org/10.1016/j.buildenv.2022.109473

Saha, S., Hiremath, R.B., Kumar bimk, B. (2021) Barriers to Adoption of Commercial Green Buildings in India: A Review, Journal of Infrastructure and Development, Volume 13, Issue 2, https://doi.org/10.1177/09749306211058499

Sánchez, P .B., Fernández, A.L., Serrano-Arcos, M.(2021) 4 - Modern age of sustainability: supply chain resource management, *Sustainable Resource Management*, Modern Approaches and Contexts, 2021, Pages 75-98

Samari, M., Ghodrati, N., & Shafiei, M. V. M. (2012) 'Implementation of Sustainable Development in Construction Industry in Penang Island', *International Journal of Emerging Trends in Engineering and Development.* Malaysia. 7: 1.Available at:https://www.researchgate.net/publication/IJETED.276961534 [accessed on 26 March 2020].

Serra, A.R.F., Martins, S.F.and Carneiro C.A.(2018) Secondary Data in Research – Uses and Opportunities, Revista Ibero Americana de Estratégia, vol. 17, no. 4, pp. 01-04, 2018Sev, A. (2011) 'A comparative analysis of building environmental assessment tools and suggestions for regional adaptations, Civil Engineering and Environmental Systems', 28 (3), pp. 231-245.

Sileyew, K.J.(2019) Research Design and Methodology, Cyberspace, DOI: 10.5772/intechopen.85731

Singh, P.H., Singh, A., Alam, F., and Agrawal, V. (2022) Impact of Sustainable Development Goals on Economic Growth in Saudi Arabia: Role of Education and Training, *Sustainability* 2022, 14(21), 14119; https://doi.org/10.3390/su142114119

Sinha, A. et al., (2013) 'Sustainable Development and Green Buildings', Drvna Industrija 64 (1), pp. 45–53. Drvna Industrija 64 (1):45–53. Available online at https://doi.org/10.5552/drind.2013.1205.[accessed on 11 December 2017].

Saaty, T. (1980) 'The Analytic Hierarchy Process', Planning, Priority Setting, Resource Allocation Advanced book program. Edition, 2, illustrated. Publisher, McGraw-Hill, 1980. Original from, the University of California. Digitized, Sep 24, 2008. ISBN, 0070543712, 9780070543713.

Satterthwaite, D.(2017) 'The impact of urban development on risk in sub-Saharan Africa's cities with a focus on small and intermediate urban centres', International Journal of Disaster Risk Reduction, Volume 26, December 2017, Pages 16-2. Available at: o https://doi.org/10.1016/j.ijdrr.2017.09.025

Sala, S., Ciuffo B., Nijkamp P.(2015) 'A systemic framework for sustainability assessment, Ecological Economics', Volume 119, November 2015, pp. 314-325. Available at: https://doi.org/10.1016/j.ecolecon [accessed on 20 June 2017].

Sandanayake, S., (2022) 'Environmental Impacts of Construction in Building Industry—A Review of Knowledge Advances, Gaps and Future Directions',

Knowledge 2022, 2(1), 139-156; https://doi.org/10.3390/knowledge2010008
Sanoff, H. (2018) 'Participatory Environmental Design', North Carolina State University. Available at:https://www.researchgate.com.
Santamouris, M., Vasilakopoulou, K. (2021) 'Present and Future Energy Consumption of Buildings: Challenges and Opportunities Towards Decarbonisation', *E-Prime - Advances in Electrical Engineering, Electronics and Energy*, (1) 100002, Available online at: https://doi.org/10.1016/j.prime.2021.100002
Sargent, R. G. (2010b) 'Verification and Validation of Simulation Tools', In Proc. 2010 Winter Simulation Conf., edited by B. Johansson, S. Jain, J. Montoya-Torres, J. Hugan, and E. Yücesan, pp. 166-183. Piscataway, New Jersey: Institute of Electrical and Electronic Engineers Inc.
Sande, I. and Phadtare, N.S. (2015) 'Comparative study of Leed and Griha Rating System. *Journal of Information, Knowledge and Research in Civil Engineering*. Available at:https://www.academia.edu. Construction & Management Student, Civil Engineering Department.
Saunders M., Lewis P., and Thornhill A. (2009) 'Understanding Research Philosophies and Approaches', Research Methods for Business Students 4, pp. 106–36. Available online at https://doi.org/10.1176/appi.ajp.162.10.1985. 2012. For Business Students Fi Fth Edition.
Sassen, M., Sheil, D., Giller, K. (2015) 'Fuelwood collection and its impacts on a protected tropical mountain forest in Uganda', *Forest Ecology and Management*, 354
DOI: 10.1016/j.foreco.2015.06.037
Searing S., Muller M., (2008) 'From a literature review to a conceptual framework for sustainable supply chain management', *Journal of Cleaner Production* 16.
Serpell, A., Kort, J. and Vera, S. (2013) 'Awareness, Actions, Drivers, and Barriers of Sustainable Construction in Chile', Technological and Economic Development of Economy, 19(2), pp. 272–288.
Schendler, A. (2010) 'Getting green done: Hard truths from the front lines of the sustainability revolution Public Affairs', Available online at https://www.researchgate.net. [accessed on 23 June 2020].
Schmidt.A (2012) 'Analysis of Five Approaches to Environmental Assessment of Building Components in a Whole Building Context', Force Technology Applied Environmental Assessment. (1), pp. 58.
Schlesinger, S., R. E. Crosbie, R. E. Gagné, G. S. Innis, Lalwani C. S. J., Loch, R. J. Sylvester, R. D. Wright, N. Kheir, and Bartos D. (1979) 'Terminology for Tool Credibility', *Simulation* 32(3), pp. 103-104.
Schlyter, A. (2000) Privatization of Council Housing in Lusaka, Zambia, Paper (draft) to
the International Research Conference Housing in the 21st century:
Fragmentation and Reorientation. The Nordic Africa Institute: Uppsala
Schoonenboom, J., and Johnson B.(2017) How to Construct a Mixed Methods Research Design, Kolner Z Soz Sozpsychol.S. 69(Suppl 2): 107–131. doi: 10.1007/s11577-017-0454-1
Shafii, F, & Othman, MZ. (2007) 'Sustainable buildings in South-East Asia: Opportunities and implementation', Paper presented at the Conference on Sustainable Building South-East Asia (SB07). Kuala Lumpur, Malaysia.
Sharad R. Khese, Hedaoo M.H, Konnur B.A(2019) 'A comparative study of rating systems in green building', International Journal of Engineering Research ISSN:2319- 6890(online),2347-5013 (print)Volume No.5, Issue Special 1, pp.

134-136.
Shari, Z.M, Jaafar, Z.F, Salleh, E. and Haw. C.L (2007)' Establishing Local Weighting Values of SBTool for Application in Malaysia', Conference on Sustainable Building South East Asia. Construction Technology and Management Centre, Kuala Lumpur, 5-7 November.
Sharifi, A., Murayama, A., (2013) 'A critical review of seven selected neighbourhood sustainability assessment tools', In Environmental Impact Assessment Review 38: 73–87. DOI: 10.1016/j.eiar.2012.06.006. Available online at https://www.osti.gov. [accessed 22 October 2016].
Shan M and Hwang B G 2018 Green building rating systems: Global reviews of practices and
research efforts. Sustainable Cities and Society 39 pp 172-180
Shen, L.Y. Li Hao, J. Tam, V.W.-Y. Yao, H. A.(2007) 'Checklist for assessing sustainability performance of construction projects', J. *Civil. Engineering Management*, 13, pp. 273–281. [CrossRef].
Short, E., Caminade, C., and Thomas, B.N., (2017) 'Climate Change Contribution to the Emergence or Re-Emergence of Parasitic Diseases', Journal of Infectious Diseases, v.10; 2017 PMC5755797
Sichali, M. and Banda J. (2017) 'The knowledge levels, attitudes and perception of green principles and practices in Zambia', *International Journal of Construction Engineering and Management* 2017, 6(5), pp. 215-220, DOI:10.5923
Simpeh, E.K and Smallwood J. (2021, June) 'Factors Influencing the Growth of Green Building in the South African Construction Industry', Department of Construction Management, Nelson Mandela Metropolitan University South Africa.
Simpeh, E.K and Smallwood J., Ahadziea, D.K. and Mensah, H. (2022) 'Analytical taxonomy of challenges to the implementation of green building projects in South Africa, International Journal of Construction Management, https://doi.org/10.1080/15623599.2020.1863172
Skillings S, Lafford T (2016) Plugging the energy gap. E3G Blog. Available at: https://www.e3g.org/library/plugging-the-energy-gap (accessed 30 July 2017).
Smith T. M., Fischlein M., Suh S., and Huelman P. (2006, September) 'Green Building Comparison of the LEED and Green Globes Systems in the US', Report, USA: Available online at http://www.nlcpr.com/Green Building Rating.pdf.
Smit, A.M., and Du Toit, F., (2015). Investigating the financial benefits of green buildings. Environmental Economics, Journal "Environmental Economics"6(3), 61-71
Simatele D., Binns T., & Simatele M., (2012) Urban Livelihoods under a Changing Climate: Perspectives on Urban Agriculture and Planning in Lusaka, Zambia, *Journal of Human Development and Capabilities*, Volume 13(2), pp. 269-293 Available at: https://doi.org/10.1080/19452829.2011.645029
Simon, B.Y., Marilyn K., and Goes. J.,(2011) 'Correlational Research PDF',
Shi, Q.; Zuo, J.; Huang, R.; Huang, J.; Pullen, S. (2013) 'Identifying the critical factors for green construction—An empirical study in China', Habitat Int. 2013, pp. 40, 1–8.
Simpeh E.K., Smallwood J.J, Ahadzie D.K., and Mensah H. (2021) 'Analytical Taxonomy of Challenges to the Implementation of Green Building Projects in South Africa, *International Journal of Construction Management*, pp. 300-301.
Simukonda, K., Farmani, R. and Butler, D. (2018) 'Causes of intermittent water supply in Lusaka City, Zambia', Water Practice and Technology13(2), pp. 335–345.

Smart Market Report (2016) 'World Green Building Trends 2016: developing markets accelerate global green growth'.

Smith, T. M., Fischlein M., Suh S., and Huelman P. (2006, September) 'Green Building Comparison of the LEED and Green Globes Systems in the US', Report, USA: Available online at http://www.nlcpr.com/Green Building Rating.pdf.

Snyder, H. (2019) Literature review as a research methodology: An overview and guidelines
Journal of Business Research, Volume 104, November 2019, Pages 333-339 https://doi.org/10.1016/j.jbusres.2019.07.039

Sridhar, K and G. Jones. (2013) 'The three fundamental criticism of the Triple Bottom Line approach: an empirical study to link sustain ability report in companies based in the Asia-Pacific region and TBL shortcomings', *Asian Journal of Business Ethics*. 2(1), pp. 91–111.

Sun, C.-Y., Chen, Y.-G., Wang, R.-J., Lo, S.-C., Yau, J.-T. and Wu, Y.-W. (2019) 'Construction Cost of Green Building Certified Residence',A Case Study in Taiwan. *Sustainability*, [online] 11(8), pp. 2195. Available at: https://www.mdpi.com/2071-1050/11/8/2195/pdf.

Son, H., Kim, C., Chong, W.K., Chou, J.S. (2011) Implementing sustainable development in theconstruction industry: contractor's perspectives in the USA and Korea. Sustain. Dev. 19(5),337–347

Song Y., Li C., Zhou L., Huang X., Chen Y., Zhang H. (2021) 'Factors affecting green building development at the municipal level: A cross-sectional study in China'. *Energy and Buildings*, 231(15), Available at: https://doi.org/10.1016/j.enbuildSutherland, R. J.

Spangenberg, J.H., (2005) 'Economic sustainability of the economy: Concepts and indicators', *International Journal of Sustainable Development* 8(1-2) DOI:10.1504/IJSD.2005.007374

Stoddart, H., Schneeberger, K., Dodds, F., Shaw, A., Bottero, M., Cornforth, J., & White, R. (2011). A pocket guide to sustainable development governance. Stakeholder Forum 2011. [Google Scholar]

Szulecka, J., (2019) 'Towards Sustainable Wood-Based Energy: Evaluation and Strategies for Mainstreaming Sustainability in the Sector, *Sustainability*, 2019, 11(2), 493. Available at: https://doi.org/10.3390/su11020493

Taber, K.S. (2018) The Use of Cronbach's Alpha When Developing and Reporting Research
Instruments in Science Education, *Research in Science Education volume* 48, pages1273–1296 Tafazzoli, M. (2017) 'Becoming Greener in Construction: Overcoming Challenges and Developing Strategies', Int. Conf. Sustain. Infrastructure, pp. 1–13. (CrossRef.).

Tafesse, S., Girma, E.Y., Dessalegn, E.,(2022) Analysis of the Socio-Economic and Environmental Impacts of Construction Waste and Management Practices, *Heliyon* v.8(3); doi: 10.1016/j.heliyon.2022.e09169

Tang, K.H.D, Foo, C.Y. H and Tan, I.S (2022) A review of the green building rating systems, Conference Series: Materials Science and Engineering, Volume 943, 2nd International Conference on Materials Technology and Energy 6-8 November 2019, Miri, Sarawak, Malaysia, DOI 10.1088/1757-899X/943/1/012060

Tashakkori, A., & Teddlie, C. (1998) 'Mixed methodology: Combining qualitative and quantitative approaches', Sage Publications, Inc.

Tavakol, M. and Dennick, R.(2011) Making sense of Cronbach's alpha, Int J Med Educ. 2011; 2: 53–55. Published online 2011 Jun 27. doi: 10.5116/ijme.4dfb.8dfd

Tendengu, S., Kapingura, F.M., and Tsegaye, A. (2022) Fiscal Policy and Economic Growth in South Africa, Economies 2022, 10(9), 204; https://doi.org/10.3390/economies10090204

Thomas, C. F. (2015). Naturalizing Sustainability Discourse: Paradigm, Practices and Pedagogy of Thoreau, Leopold, Carson and Wilson: Ph.D Thesis: Arizona State University (CrossRef.)

Thomas,G.J.M. and Liew, D.(2022) Observational studies and their utility for practice, Journal List Aust Prescr v.41(3); 2018 Jun PMC6003013, doi: 10.18773/austprescr.2018.017

Thomas. L. (2022). Cross-Sectional Study | Definition, Uses & Examples, Scribbler PublicationThompson L., and Roux J (2010) 'The Struggle for Integrated Sustainable Settlements. Combining qualitative and quantitative approaches', Thousand Oaks, CA: Sage. South Africa.

Thurlow, J., Zhu, T.J. and Diao, X.S. (2012) Current Climate Variability and Future Climate Change: Estimated Growth and Poverty Impacts for Zambia. Review of Development Economics, 16, 394-411.

Tilly, C. (1984) 'Big structures, large processes, huge comparisons', Russell Sage Foundation. ISBN:978-0-87154-880- USA.

Tian, G., & Li, J. (2019) How Does Infrastructure Construction Affect Economic Development along the "Belt and Road": By Promoting Growth or Improving Distribution? Emerging Markets Finance and Trade, Volume 55, 2019 - Issue 14: Symposium: On the Way to the Silk Road: Trade, Investment and Finance in Emerging Economies, Pages 3332-3348. Available at: https://doi.org/10.1080/1540496X.2019.1607725

Timans, R., Wouters, P., & Heilbron, J.(2019) Mixed methods research: what it is and what it could be, Theory and Society volume 48, pages193–216 (2019) Timilsina, G.R., Hochman, G. and Fedets, I. (2016) 'Understanding energy efficiency barriers in Ukraine: insights from a survey of commercial and industrial firms', *Energy*, 106, pp. 203-211.

Tessen, F.,Taipale, K., and Bethge (2015) Sustainable Buildings and Construction in Africa, Fedral Mininstry for the Environment and Nuclear Safety (BMU)

Toronto City Council (2020) 'Toronto Green Building Standards', Toronto, Canada.

Towell B., et al (2013) 'World GBC A Guide for Green Building Rating Tools',

Tshwane K., Essah E., and T. Dixon T.(2014) 'Investigating the level of awareness of building assessment tools in the construction industry of Botswana', Annual ARCOM Conference, 1-3Sept 2014, Portsmouth, U.K., pp. 23-32. Available at http://centaur.reading.ac.uk.

Umar.A.U and Khamidi.M.E. (2012) 'Determined the Level of Green Building Public Awareness: Application and Strategies', Civil Engineering Department, University Teknology PETRONAS Malaysia. *International Conference on Civil, Offshore and Environmental Engineering*, Kuala Lumpur Malaysia.DOI:10.1314012.15095.6480.

United Nations Conference on the Human Environment (UNCHE), 5-16 June 1972, Stockholm.

United Nations Economic and Social Council (2020) Progress towards the Sustainable Development Goals Report of the Secretary-General [accessed 12 December 2022].

UN Department of Economic and Social Affairs Sustainable Development, UN. (2020) 'Sustainable cities and human settlements', [online] Available at:

https://sdgs.un.org/topics/sustainable-cities-and-human-settlements.
USGBC, LEED 4: (2012) 'Building Design and Construction', in 5th Public Comment Draft, 2012, USGBC: 158.
UN Department of Economic and Social Affairs Sustainable Development, (UNESASD). (2020) 'Sustainable cities and human settlements', [online] Available at: https://sdgs.un.org/topics/sustainable-cities-and-human-settlements.
United Nations General Assembly (1987) Report of the World Commission on Environment and Development: Our Common Future [accessed 12 December 2022].
UNEP. (2017). Zambia. In UNEP, Atlas of African Energy Resosurces (pp. 302-305). Nairobi: United Nations Environment Programme (UNEP). Retrieved January 24, 2018,from https://www.icafrica.org/fileadmin/documents/Publications.
UNEP (2016) 'Building and climate change', UNEP. Available online at http//www.greeningtheblue.org [accessed 10 December 2017].
UN-Habitat (2016) 'The Housing need in Zambia', [online] Available at: http//www.habitatforhumanityzambia.org [accessed 12 December 2019].
UNHRP (2019), Housing the Urban Poor. http://www.unhabitat.org/unhrp
UNICEF (2011) 'Impact Evaluation of the Sanitation Programme in Zambia', [online] Available at: http//www.unicef.org [accessed 12 January 2017].
URBANET (2022) publication, Available online at https://www.urbanet.info/the-global-housing-crisis/
Varone, Frédéric & Aebischer, Bernard. (2006) 'Energy efficiency: The challenges of policy design', *Energy Policy*. 29, pp. 615-629. 10.1016/S0301-4215(00)00156-7.
Venter, Z.S., Shackleton, C.M., Van Staden, F., Selomane, O. and Masterson, V.A. (2020) 'Green Apartheid: Urban green infrastructure remains unequally distributed across income and race geographies in South Africa', *Landscape and Urban Planning,* [online] 203: 103889. Available at: https://reader.elsevier.com
Veselý, A., (2022) problem structuring, an initial step in policy analysis, Central European Journal of Public Policy,Vol. 2—№ 2—December 2008—pp 68–81 ISSN 1802–4866
Vierra, S. (2022) 'Green Building Standards And Certification', Whole Building Design Guide
Vice President's Office, United Republic of Tanzania (2019), State of Environment Report 3, en-1592550740-State of Environment_Third Report 2019.
Vigovskaya, A., Aleksandrova,O., Bulgakov, B.(2018) Life Cycle Assessment (LCA) of a LEED certified building, IOP Conference Series: Materials Science and Engineering, Volume 365, Issue 2, DOI 10.1088/1757-899X/365/2/022007
Visagie, J. and Turok I. (2020) 'Getting urban density to work in informal settlements in Africa', International Institute for Environment and Development. Vol. 32(1), Available at: https://doi.org
Walliman (2001) 'Your Research Project – A Step-By-Step Guide for the First-Time', *Researcher.* Sage Publications, London, 2001: 322, ISBN 0 761 96539 4.
Wang, T., Li, X., Liao, P.-C. and Fang, D. (2016) 'Building energy efficiency for public hospitals and healthcare facilities in China: barriers and drivers', *Energy*, Vol. 103, pp. 588-597.
Wang, Y., Zhang S., Su Y., Deng X. (2018) 'Key Factors to Green Building Technologies Adoption in Developing Countries: The Perspective of Chinese Designers', *Sustainability*, 10(11), pp. 4135; Available online at https://doi.org/10.3390/su10114135 [accessed 22 October 2016].

Wang, L.; You, W.; Zhou, Y., Meng, F. (2022) How Does Green Supply Chain Management Promote the Success of Crowdfunding Projects? Empirical Research Based on the QCA Method. Sustainability 2022, 14, 12312. https://doi.org/10.3390/

Welman, J. and Kruger, S. (2001) 'Issues Affecting the Adoption and Usage of Mobile Instant Messaging in Semi-Rural Public Schools of South Africa for Learning, Research Methodology', Oxford University Press, Cape Town.

Wen, B., Musa, N., Chuen, C., Ramesh, O.S., Liang, L., Wang, W.(2020) 'Evolution of sustainability in global green building rating tools', *Journal of Cleaner Production* Volume 259, 20 June 2020, 120912, https://doi.org/10.1016/j.jclepro.2020.120912

WGBT, World Green building trends smart market report (2016) https://fidic. org/ sites/default/world/world green building trend samrt market report.

Whiting, P., Savović, J., Simera, I., Mallett, S. and Woiff, R. (2017) 'A proposed framework for developing quality assessment tools', BioMed Central.

Wilson, J (2018) 'How can architects and designers increase social value in the built environment?' Social Sustainability and Architecture, Vol. 27(7).

William, R., Goodwell, A., Richardson, M., Le, P.V.V., Kumar, P. and Stillwell, A.S. (2016) 'An environmental cost-benefit analysis of alternative green roofing strategies', *Ecological Engineering*, 95, pp. 1–9.

Williams, C. (2007) 'Research Methods', *Journal of Business and Economics Research* 5 (3), pp. 65–72.

William, R., Goodwell, A., Richardson, M., Le, P.V.V., Kumar, P. and Stillwell, A.S. (2016) 'An environmental cost-benefit analysis of alternative green roofing strategies', *Ecological Engineering*, 95, pp.1–9.

Williams, D. S., Máñez Costa, M., Sutherland, C., Celliers, L., & Scheffran, J. (2019). Vulnerability of informal settlements in the context of rapid urbanization and climate
change. Environment and Urbanization, 31(1), 157-176.
doi:10.1177/0956247818819694

Wimala, M., Akmalah, E. and Sururi, M.R. (2016) 'Breaking through the Barriers to Green Building Movement in Indonesia: Insights from Building Occupants', *Energy Procedia*, 100, pp. 469–474.

Windapo, A. O. (2014) 'examination of green building factorsin South Africa construction industry', Department of Construction Economics and Management, University of Cape Town, University Avenue South, Rondebosch 7701, South Africa; E-Mail: abimbola.windapo@uct.ac.za;

Windapo, A. O., (2014). Examination of Green Building Factorsin South Africa Construction Industry. Department of Construction Economics and Management, :6092-6096. Available at :<https://www.mdpi.com/2071-1050/6/9/6088> [accessed on 21 Februar 2017].

Vitale, P., Alfano, V.,Tommaso Pastore, T., Menna, C., Maffettone, P., Asprone, D. (2021) 'Toward a Holistic Rating System: An Attempt to Expand the Boundaries of Building Sustainability Using SDGs', *Front. Built Environ*., Sec. Sustainable Design and Construction, Volume 7 - 2021 | https://doi.org/10.3389/fbuil.2021.679014

Wong, S.Y., Low, W.W., Wong, K.S., and Tai, Y.H. (2021) Barriers for green building implementation in Malaysian construction industry, IOP Conference Series: Materials Science and Engineering, Volume 1101, The 13th International UNIMAS Engineering Conference 2020 (ENCON 2020) 27th - 28th Oct 2020,

Kuching, Malaysia
Wong, S.Y., Susilawati, C. Miller, W. and Mardiasmo D. (2015) ‘A Comparison of International and Australian Rating Tools for Sustainability Elements of Residential Property’, Cobra 2015, RICS, School of Civil Engineering and Built Environment, Queensland University of Technology.
Woolley (2016) ‘Building Materials, Health and Indoor Air Quality’, 1st Edition, ISBN 9781315677965.
World Bank publication (2018) ‘Building the Market for GB’, GEF/R.8/02/Rev.01 [online] Available at: www.thegef.org.
World Bank publication (2023) ‘Zambia Economic Recovery Report’, , [online] Available at: https://www.worldbank.org/en/country/zambia/overview#
World Bank publication (2020) ‘Zambia Water Supply and Sanitation Sector Diagnostic Narrowing the Gap between Policy and Practice’, [online] Available at:
World Economic Forum publication (2022), Available at: https://blogs.worldbank.org
World Green Building Council (2018) ‘About GB’, https://worldgbc.org/rating-tools.
Wu, Z., Jiang, M., Cai, Y., Wang, H., and Shenghan Li, S., (2019) What Hinders the Development of Green Building? An Investigation of China, Int J Environ Res Public Health. 2019 Sep; 16(17): 3140. Procedia Environmental Sciences
Yamany, E., Afifi, M., Hassan,A. (2016) Applicability and Implementation of U.S. Green Building Council Rating System (LEED) in Egypt (A Longitudinal study for Egyptian LEED Certified Buildings), *Procedia Environmental Sciences*,Volume 34, 2016, Pages 594-604
Yan, H., Ding, G., Feng, K., Zhang, L., Li, H., Wang, Y., & Wu, T. (2020). ‘Systematic evaluation framework and empirical study of the impacts of building construction dust on the surrounding environment’, *Journal of Cleaner Production*, 275, 122767. https://doi.org/10.1016/j.jclepro.2020.122767 [Crossref]
Yang. T., and Kuo,C.(2003) "A hierarchical methodology for the facilities layout design problem,"European Journal of Operational Research, vol. 147, pp. 128 - 136, 2003.
Yao, F., Liu, G., 1, Ji, Y.,Tong, W., Du, X., Li, K., Shrestha, A. and Martek, I.(2020) Evaluating the Environmental Impact of Construction within the Industrialized Building Process: A Monetization and Building Information Modelling Approach, Int J Environ Res Public Health. 2020 Nov; 17(22): 8396.
Yudelson, J. (2016) ‘Reinventing green building: Why certification systems aren't working and what we can do about it’, New Society Publishers [CrossRef]
Zainon, N, Mohd-Rahim, F.A., Sulaiman, S., Abd-Karim, S. B., Hamzah, A. (2017). Factors Affecting the Demand of Affordable Housing Among the Middle-Income Groups in Klang Valley Malaysia. Journal of Design and Built Environment Special Issue, 17(2). [CrossRef]
Zararsız, A., Oztürk, F. (2020) Estimation of health risks associated with household dust contamination in Bolu (Turkey). Düzce Üniversitesi Bilim ve Teknoloji Dergisi 8:2245–2265
Zarco-Periñán, Irene M. Zarco-Soto, I.M., Javier Zarco-Soto, J., José L. Martínez-Ramos, J.L., and Sánchez-Durán, R., (2022) ‘CO2 Emissions in Buildings: A Synopsis of Current Studies’, *Energies.* pp. 15, 6635. Available at: https://doi.org/10.3390/en15186635
Zhang, Y., & Wang, Y. (2013) ‘Barriers' and policies' analysis of China's building energy efficiency’,Energy Policy, 62 (November), pp. 768-773. Available at:

http://dx.doi.org/10.1016/j.enpol.2013.06.128 [accessed 17 October 2019]
Zhang, X., Zhan, C., Wang, X. and Li, G. (2019) 'Asian green building rating tools: A comparative study on scoring methods of quantitative evaluation systems', Journal of Cleaner Production, 218, pp. 880–895.
Zhang, C., Cui, C., Zhang, Y., Yuan, J., Luo, Y., Gang, W., (2019) A Review of Renewable Energy Assessment Methods in Green Building and Breen Neighborhood Rating Systems, *Energy Build*. 195 68–81, https://doi.org/10.1016/j.enbuild.2019.04.040
Zhao, X., Zuo, J., Wu,G., and Huang C.(2019) 'A bibliometric review of green building research 2000–2016', Architectural Science Review', vol. 62, pp. 74-88 |
Zhong Y. and Wu P.(2015) 'Economic sustainability, environmental sustainability and constructability indicators related to concrete- and steel-projects,' Journal of Cleaner Production, Volume 108 (1), pp. 748-756. Available at: https://doi.org/10.1016/j.jclepro.2015.05.095.
Zhong, X., Hu, M., Deetman, S., Steubing, B., Hai Xiang Lin, X.H., Glenn Aguilar Hernandez, G.A., Harpprecht, C., Zhang, C., Tukker A. & Behrens, P.(2021) 'Global greenhouse gas emissions from residential and commercial building materials and mitigation strategies to 2060', Nature Communications, 12 (6126)
Zuniga-Teran, A., Staddon, C., Laura de Vito, Gerlak, A.K., Sarah, W., Schoeman, Y.(2019) Challenges of mainstreaming green infrastructure in built environment professions, *Journal of Environmental Planning and Management*, Volume 63, 2020 - Issue 4
pp. 710-732 |
Žukauskas, P., Vveinhardt, J., and Andriukaitienė, R.(2017) Philosophy and Paradigm of Scientific Research, Management Culture and Corporate Social Responsibility, DOI: 10.5772/intechopen.70628
Zulu, A. (2019) 'Assessment of Solid Waste Management in Residential Townships in Lusaka Zambia'. *Acta Scientific Agriculture* 3(11): 62–66. https://doi.org/10.31080/ASAG.2019.03.068
Zulu. E., Zulu, S., Chabala, M., Musonda, I., Kavishe, N., Nicholas Chileshe, N.(2022) 'Challenges and advocated solutions for environmental protection legislation for building infrastructure projects in developing countries: Evidence from Zambia', *Project Leadership and Society*, Volume 3, December 2022, 100056
Zuo J. and Zhao Z. (2014) "Green Building Research-Current Status and Future Agenda: A review," *Renewable and Sustainable Energy Reviews*, vol. 30,.
Zuo, J., Pullen S., Rameezdeen R., Bennetts H., Wang, Y. Guozhu Mao, G., Zhou Z., (2014). 'Green Building Research-Current Status and Future Agenda',
Zuo, J., Xia, B., Chen, Q., Pullen, S. & Skitmore, M. (2016). 'Green building rating for office buildings - Lessons learned'. *Journal of Green Building*, 11(2), pp. 131-146. https://doi.org/10.3992/jgb.11.2.131.1.

APPENDICES

APPENDIX A: Ethical Clearance

THE UNIVERSITY OF ZAMBIA

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APPROVAL OF STUDY

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21st December, 2022

REF NO. NASREC-2017-DEC-014

Mutinta Mwape Sichali
The University of Zambia
School of Engineering
Department of Civil and Environmental Engineering
P.O. Box 32379
LUSAKA

Dear Ms. Sichali,

RE: "MODELLING A GREEN BUILDING ASSESSMENT TOOL FOR ZAMBIA'S LOW COST HOUSING"

Reference is made to your protocol dated as captioned above. NASREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

Review Type	Ordinary Review	Approval No. NASREC-2017-DEC-014
Approval and Expiry Date	Approval Date: 21st December, 2017	Expiry Date: 20th December, 2018
Protocol Version and Date	Version - Nil.	20th December, 2018
Information Sheet, Consent Forms and Dates	• English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed. Expedited

Excellence in Teaching, Research and Community Service

APPENDIX B: Information sheet for participants – survey

PhD research study: Modelling a Green Building assessment tool for low-cost houses in
Zambia.
Protocol number HSSREC IRB NO. 0006465

Introduction

My name is Mutinta Mwape Sichali, a student at the University of Zambia. I am carrying out
research on the development of green building assessment tools for low-cost housing in Zambia.
I am going to give you information and invite you to participate in the study. You need
not decide to participate or not to participate today. You may need to discuss this issue with
anyone you feel comfortable with about the investigation.

Should this consent form contain any words you do not understand, kindly stop me and I will
clarify with you. If you have questions now or later, you are free to ask me or any member of
the research team.

What is the purpose of the study?

The study is aimed at investigating the use of tools, the barriers, and drivers to utilizing green
building tools (GBTs) and to develop local assessment tools for the design and
construction of sustainable low-cost houses in Zambia and the Southern African region. I
believe you can help by telling me what you know about GBTs and what would
influence or discourage you from using the tools.

What will participation involve?

You will be asked questions and given responses to choose from. Your responses will be filled in for you or you can fill it out yourself. There are about 27 questions and a knowledge test table for you to fill in. The session is meant for you to express your opinions concerning the use and factors affecting utilization of GBTs. Also, through the questionnaire you will be asked to select the preferred criteria to use in assessing green buildings (GBs).

Your personal information such as name or address will not be written on the questionnaire in order to keep your information confidential.

Procedures

I am inviting you to take part in this research project so that I can learn more about the utilization of GBTs. If you accept, you will be asked to sign a form to indicate that you are willing to participate.

You will be asked to fill answers in the questions provided to you by one of my research assistant. If you do not want to fill in the questionnaire, the person will assist you to do so. When you have completed the questions, the paper will be collected by the person. If you do not wish to answer any of the questions included in the paper, you may skip them and move on to the next question. The information recorded is confidential, your name is not being included on the forms, only a number will identify you, and no one else except myself and my assistants will have access to the paper.

Duration

The questions will take about thirty minutes to complete.

Risks

The investigation will not involve collecting anything from you for testing or measurement.

Most of the questions that will be asked are general, but you may skip the questions which
you are not comfortable with.

Benefits

There will be no direct benefit to you as an individual. However, the information you will
give will help me investigate more about GBTs and enable the development of
an assessment tool that can be used by the building industry in future.

Reimbursements

You will not be provided with any incentive to take part in the research.

Confidentiality

The research will take place in the building industry, and I will not be sharing information
about you to anyone outside of the research team. The information that we collect from this
research project will be kept private. Any information about you will have a number on it
instead of your name. Only the researchers will know what your number is, and we will lock
that information up with a lock and key. It will not be shared with or given to anyone.

Sharing the Results

Nothing that you tell us today will be shared with anybody outside the research team, and
nothing will be attributed to you by name. The knowledge that I get from this research will
be shared with you before it is made widely available to the public. Each participant will

receive a summary of the results and I will publish the results so that other interested people
may learn from the research.

Right to Refuse or Withdraw

You do not have to take part in this research if you do not wish to do so, and choosing to
participate will not affect your job or job-related evaluations in any way. You may stop
participating in the [discussion/interview] at any time that you wish without your job being
affected. I will give you an opportunity at the end of the interview/discussion to review your
remarks, and you can ask to modify or remove portions of those, if you do not agree with my
notes or if I did not understand you correctly.

Who to call for questions or problems?

You can contact the principal investigator, Mutinta Mwape Sichali on +260979940038 for
any questions or complaints about the study.

You can also contact the University of Zambia, Natural Science and Research Committee
(NASREC) if there are questions about your rights or if you have any concerns.

The contact information is:

The Chairperson, NASREC, P.O Box 32379,

Lusaka, Zambia.

Telephone: 0211 290 258.

Email: director@drgs.unza.zm

APPENDIX C: Consent form

CONSENT FORM

What does my signature (or thumb print/mark) on this consent form mean?

My signature (or thumb print/mark) on this form means:

•I have been informed about this study's purpose, procedures, possible benefits, and risks.

• I have been given the chance to ask questions before I sign.

• I have voluntarily agreed to participate in this study.

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Name of participant Signature of participant Date

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Name of person obtaining Consent Signature of person obtaining consent Date

APPENDIX D: Sample of research instrument – questionnaire

UNIVERSITY OF ZAMBIA SCHOOL OF ENGINEERING,

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

STRUCTURED INTERVIEW QUESTIONNAIRE

TOPIC: DEVELOPING A GREEN BUILDING ASSESSMENT TOOL FOR LOWCOST HOUSES IN ZAMBIA.

Serial Number …………………………………………………...

Date of interview: ……………………………………………….

Name of interviewer: ……………………………………………...

INSTRUCTIONS FOR INTERVIEWER

1. Introduce yourself to the respondents.
2. Do not write the respondents on the questionnaire.
3. Ask all questions in the order they are arranged.
4. Indicate the answers to the question by ticking in the box provided and write your responses to open ended questions in the space provided.
5. Assure the respondents that all information will be treated as confidential and used for the purpose it is intended for.

INSTRUCTIONS: **PLEASE TICK CORRECT ANSWERS IN THE BOX AND WRITE ANSWERS IN THE SPACE PROVIDED.**

SECTION A: DERMOGRAPHIC DATA

1) What is your profession?
a) Architect ☐
b) Quantity Surveyor ☐
c) Engineers ☐
d) Developer ☐
e) Evaluation surveyor ☐
f) Planner ☐
2) How long have you been working in the construction industry?
a) 0-5 ☐
b) 6-10 ☐
c) 11-15 ☐
d) 16-20 ☐
e) > 20

3) What has been the bulk of your projects in the last 10 years?
a) Office buildings ☐
b) Health buildings ☐
c) Learning institutes ☐
d) Residential ☐
e) Other (please specify)
……………………………………………………..

4) Have you ever used a green building rating tool (GBTs)
Yes No
☐ ☐

5) If yes in 6 above, how did you acquire knowledge in rate build up? Through Formal training, on job training, not applicable other (please state) ……
Internate training media through green building (GB) projects
☐ ☐ ☐ ☐

6) How much do you know about GBTs?
☐ very good knowledge ☐good knowledge ☐very poor knowledge ☐no knowledge at all

7) Please tick all the factors that would influence you using GBTs.
☐availability of GBTs on the market ☐ adaptable to the environment
☐ low cost of GB assessment ☐ increased experience in GBTs ☐ building byelaws on GB ☐ presence of local GBTs ☐ environmental benefits
☐social economic benefits

8) What assessment tools from the ones listed below have you used?

a) Building Research Establishment Environmental Assessment (BREAM) ☐
b) Leadership in Energy and Environmental Design (LEED) ☐
c) Comprehensive Assessment System for Building (CASBEE) ☐
d) Green Star ☐
e) Sustainability Building Assessment Tool ☐
f) German Sustainable building certificate (DGNB) ☐
g) None of the above ☐
h) Other please specify below. ☐

…………………………………………………………………………………………

9) If the answer in 8 is none of the above which assessment tools have you come across?

a) Building Research Establishment Environmental Assessment (BREAM) ☐
b) Leadership in Energy and Environmental Design (LEED) ☐
c) Comprehensive Assessment System for Building (CASBEE) ☐
d) Green Star ☐
e) Sustainability Building Assessment Tool ☐
f) German Sustainable building certificate (DGNB) ☐
g) Other please specify below.

…………………………………………………………………………………………

10) Do you include sustainability parameters in the design and construction process of your of your projects?

☐ yes ☐ No

11) If your answer in 4 is yes which of the following parameters, do you use

a) energy serving ☐
b) water management ☐
c) materials and resources ☐
d) health and wellbeing ☐
e) Sustainable sites ☐
f) waste management ☐
g) pollution control ☐
h) transportation ☐
i) social-economic cohesion ☐
j) education ☐
k) Other please specify below.

……………………………………

12) What was the experience in using any of the above assessment tools?

a) It was easy ☐
b) it was very interesting ☐
c) it covered all aspects of sustainability ☐
d) it increased your knowledge on sustainability ☐
e) it was suitable for the building under study ☐

Other please specify below.
…………………………………………………………………………………………
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13) On a scale of 1-5 1 being easy to use and 5 being most difficult to use. Kindly rate the following assessment tools listed below.

a) Building Research Establishment Environmental Assessment (BREAM) ☐
b) Leadership in Energy and Environmental Design (LEED) ☐
c) Comprehensive Assessment System for Building (CASBEE) ☐
d) Green Star ☐
e) Sustainability Building Assessment Tool ☐
f) German Sustainable building certificate (DGNB) ☐

14) Have you used the Zambia Sustainability Housing Guidelines of the Ministry of Local government to guide your projects?

a) Yes ☐
b) No ☐

15) If you are using the guidelines, what parameters have you taken from it?

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16) If you are not using the guidelines what has prevented, you from using them?
    a) Have not heard about them ☐
    b) were difficult to follow it ☐
    c) were not relevant for the local environmental ☐
    d) access was not available online ☐
    e) Other please specify below. ☐

…………………………………………………………………………………………
……

17) What challenges do you have in carrying out projects with GB strategies?

a) the GBTs were not available Have not heard about them ☐
b) the GBTs are difficult to follow ☐
c) the GBTs are not relevant for the local environmental ☐
d) the GBTs are not accessible ☐
e) Other please specify below.

………………………………………………………………………………………
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SECTION B KNOWLEDGE OF GREEN BUILDINGS

Using the chart below please tick which answer is appropriate for the statement.

GB knowledge Statements					
Likert scale	Strongly disagree	disagree	Neither agree nor disagree	agree	Strongly agree
Concepts of GB					
The United Nations Env. Program see the issue of sustainable development as environment protection and resource-efficiency at least for our generation.					
Maintaining biodiversity means maintaining the number and variety of living organisms					
Sustainable development relies upon a complex interaction of environmental processes, culture, economy, and human activity air quality					
Green Buildings					
GB strategies can maximize both the social-economic and environmental performance of buildings.					
HCFC or halogens found in some HVAC system do not affect the ozone layer					
*Indoor Air Quality (IAQ) refers to the air quality in buildings and not around buildings and structures					
Green fatigue is disorder from living and working in "sick" or toxic buildings					

GB knowledge Statements					
Likert scale	Strongly disagree	disagree	Neither agree nor disagree	agree	Strongly agree
Potable water can be replaced with grey water for landscaping irrigation					
Green roofs provide temperature and sound isolation					
In Rain gardens, permeable pavements, vegetated roof, provide for stormwater infiltration					
GB rating					
Green building cost more than traditional buildings					
The main criteria for assessment in GB are energy, materials, water, sustainable site, transport, health and well-being, pollution.					
In all rating tools independent assessors are required to undertake the assessment					
EGB					
Heat Island effect is not generated from rooftops, parking areas, streets, and driveways					
Smart transportation include access to public transit,					
Having respect for other cultures is necessary for sustainable development.					

SECTION C ASSESSING THE RATING TOOLS

18) Which of the following criteria extracted from various building assessment tools would you consider important for assessing sustainable buildings? (Tick all that apply)

a) Energy efficient buildings ☐
b) Sustainable building materials ☐
c) Water recycling techniques ☐
d) Passive solar design ☐
e) Land use and Ecology ☐
f) Solid waste management ☐
g) 3Rs (Reduce, Reuse, Recycle) ☐

19) Do you think the ones ticked above are adequate to be used in assessing the sustainability of building in Zambia Have you used in Zambia?

a) ☐ yes
b) ☐ No

Other reasons (please specify below)

……………………………………………………….

20) If your answer in Q.18 is No which other criteria is required to enhance this?

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………………………………………………………………………………………
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21) Without the use of any assessment tools how are you assessing the sustainability of buildings in your project?

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22) On a scale of 1-5 with 1 being least important and 5 being most important how would you rate the following sustainability criteria?

a) Energy and water ☐
b) Thermal comfort ☐
c) Internal comfort and delighting ☐
d) Passive solar design ☐
e) Land use and Ecology ☐
f) Solid waste management ☐

23) When are building considered for sustainability which five factors can you choose as important for sustainable buildings?

a) The material component source of building ☐
b) The energy usage in the building ☐
c) Land use and ecology ☐
d) The life cycle cost of the design and construction process ☐
e) Neighborhood interaction/ Health and wellbeing / safety ☐
f) The internal comfort of the buildings ☐
g) Management of building process ☐

24) On a scale of 1-5 with 1 being least significant barriers and 5 being most significant. Kindly rate the following barriers to development of assessment tools for buildings in Zambia.

a) Lack of regulation and policy direction from government ☐
b) Unavailability of rating tools on the market ☐
c) Lack of technical skills to develop tools ☐
d) Expense of developing assessment tools ☐
e) Fewer developers championing the use of assessment tools ☐
f) Lack of incentive for developing sustainable buildings ☐
g) Inadequate cost data for sustainable buildings developing sustainable buildings☐

25) On a scale of 1-5 with 1 being least significant driver and 5 being most significant driver. Kindly rate the following drivers to development of assessment tools for buildings in Zambia.

a) Reduced environmental and social and economic cost of buildings ☐
b) Reduced cost running assessment tools ☐
c) Improved health and wellbeing of school children ☐
d) Interest of developers in sustainable school buildings ☐
e) Promotion and recognition of school buildings built in a sustainable way ☐
f) Regulation and policy enforcing the development of sustainable buildings ☐
g) Availability of green products and materials on the market ☐

26) What are the benefits of using assessment tools in the development of buildings?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
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27) What other issues are important in the use or development of assessment tools for Zambian buildings?
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The End!
Thank you for your time.

APPENDIX E: Information sheet for interviews

PhD research study: Modelling a Green Building assessment tool for low-cost houses in Zambia.

Protocol number HSSREC IRB NO. 0006465

Introduction

My name is Mutinta Mwape Sichali, a student at the University of Zambia. I am doing research on the modelling of green building assessment tools for low-cost housing in Zambia

I am going to give you information and invite you to participate in the study. You need not decide to participate or not to participate today. You may need to discuss this issue with anyone you feel comfortable with about the interview. Should this consent form contain any words you do not understand, kindly stop me and I will clarify with you. If you have questions now or later, you are free to ask me or any member of the research team.

What is the purpose of the study?

The study is aimed at investigating the use of tools, the barriers, and drivers to utilizing green building tools (GBTs) and to develop local assessment tools for the design and implementation of sustainable low-cost houses in Zambia and the Southern African region. I believe you can help me by telling me what you know about GBTs, the preferred criteria for assessing GB and what would influence or discourage you from using the tools.

Why have you been chosen?

You are being requested to take part in the study because you have you have wide experience in the building industry, you have participated in GB projects, and you have a strategic position in your firm or organization. Your expert opinion will greatly contribute to bringing out what would be good GB strategies for Zambia.

What will participation involve?

You will be interviewed at a place of your convenience. The interview will take place between 30-40 minutes. The session is meant for you to express your opinions concerning the implementation of a GB assessment model for Zambia. The interview will be audio recorded and notes will be taken down as we discuss with you. Another person will be in attendance to help me take down the notes. Recordings of the interviews will be transcribed later as well as the written text. After transcribing them, the recordings will be destroyed.

You are free to ask for a written copy of the report at the end of the project. At the presentation of results, your own words will be used but no identifiers linked to you will be used.

Risks and benefits

This study has no obvious risks to you physically or otherwise. Please note that no compensation will be made to you for participating in the study.

Please be informed that;

You can decide not to participate in the study without any consequences.

You can decide not to answer questions that you do not want. You can decide to withdraw from the study at any stage without consequences. You can no decide whether to participate in the study or not. You are also free to withdraw from the interview at any time without giving reasons. If you decide to take part, this information sheet will be given to you and l will ask you to sign a consent form to affirm your participation.

If you have further questions, please contact me or any of my supervisors using the under listed addresses:

Investigator
Mutinta Mwape Sichali
Department of Environmental Health
School of Public Health

UNZA

Supervisors

Prof. Muya Mundia

Department of civil and environmental engineering

School of Engineering

UNZA

Dr. Balimu Mwiya

Department of civil and environmental engineering

School of Engineering

UNZA

Consent form:

l have read, understood, and been given a copy of the information sheet. I desire of my own free will to participate in the study.

Signature: --- Date: ------------------------------

APPENDIX F: Interview guide

1. How can you describe the adaptation of green buildings strategies in Zambia?

2. What factors would influence you to using GBTs?

3. Which GBTs can you consider appropriate for the Zambia building industry and why?

4. What sustainability criteria would you consider appropriate to achieve GB in Zambia?

5. What do you think is lacking in the current GB assessment criteria that you feel should be included in the GBTs appropriate for Zambia

6. What would you consider as barriers in implementing GB in the Zambia building industry?

7. What would you consider as drivers in implementing GB in the Zambia building industry?

8. How has the Zambia Sustainability Housing Guidelines influenced sustainable housing development in Zambia?

9. How would you use the Guidelines to aid in planning, designing and construction of green housing?

10. How do you think the government can influence the development of GBTs in Zambia?

11. How can GB parameters be applied in the building byelaws?

12. How should GBTs be promoted and applied in the building industry?

APPENDIX G: Comparison of international GBTs

Comparison items	**The mainstream sustainable/green building rating tools**					
	LEED	***BREEAM***	***SBTool***	***CASBEE***	***BCA-GM***	***ESGB***
Version	V2.x	BREEAM-2008	SBTool-2007	Update to 2008	V3.0	ESGB-2006
Organizations providing rating tools	USGBC(*non-profit third party*)	BRE(*non-profit third party*)	iiSBE *(international non-profit collaboration*)	JaGBC (*joint of government, industry, academy*)	BCA (*dominated by national government*)	MHURD(*dominated by national government*)
Market-orientated	Fully market-orientated and strong market penetration	Fully market-orientated and strong market penetration	Moderate market-orientated	Moderate market-orientated and moderate government involvement	Moderate market-orientated and high government involvement	Low market-orientated and high government dominating
Accredited professional	LEED AP	BREEAM AP	Depending on local third part, and iiSBE provides skill and education supports	CASBEE AP	Certified Green Mark Manager & Green Mark Professional	null
Flexibility	Increasing flexibility in USA, and relative moderate flexibility in the overseas	Increasing flexibility in UK, and relative moderate flexibility in the overseas	High flexibility around the world	Increasing flexibility in Japan, and relative low flexibility in the overseas	Increasing flexibility in Singapore, and only focus on native field	Low flexibility and more improvement required
Usage domains (building types)	Residence, school, retail, commercial building, multi-function building, healthcare	Residence, office, retail, industry unit, court, education, healthcare, prison, unusual building type, multi-function building	Almost any type of the building	Residence, temporary construction, heat island, multi-function building, etc.	Residential and non-residential building	residence, office, hotel, commercial building
Assessment issues	Sustainable sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, Innovation & Design process	Management, Energy, Transport, Pollution, Materials, Water, Land Use and Ecology, Health and Wellbeing, Pollution (***Eco Homes only contains the former eight issues***)	Site Selection, Project Planning and Development, Energy and Resource Consumption, Environmental Loadings, Indoor Environmental Quality, Service Quality, Social and Economic aspects, Cultural and Perceptual Aspects	***Building environmental quality issues:*** Indoor Environment, Quality of Service, Outdoor Environment on Site; ***Environmental Load issues:*** Energy, Resources & Materials, Off-site Environment	Energy Efficiency, Water Efficiency, Indoor Environmental Quality, (***all included by NB and EB***); Environmental Protection, Other Green Features(***Special for NB***); Building Management & Operation, Innovation(***Special for EB***)	Land saving & Outdoor Environment, Energy saving and usage, Water saving and usage, Material saving and usage, Indoor Environment Quality, Operational Management
Life cycle coverage (building phases)	Programming, Design, Construction, Operation	Programming, Design, Construction, Operation	Programming, Design, Construction, Operation	Programming (*Tool-0, underdevelopment*), Design, Operation, Renovation	Programming, Design, Construction, Operation	Programming, Design, Construction, Operation
Weighting system	Null (*LEED V3.0 will contain a weighting system*)	Yes	Yes (*the iiSBE provides a default weighting system, and the regional third parts can develop a new one*)	Yes	Null	Null
Rating benchmarks and labeling systems	***Total points: 69***. 26-32 points (*Certified*), 33-38 points (*Silver*), 39-51 points (*Gold*), 52 or more points (*Platinum*)	*Total percentage of credits achieved,* for example, **Eco Homes**: 36%-47% (*Pass*), 48%-57% (*Good*), 58%-69% (*Very good*), 70% and more (*Excellent*).	**Score:** -1 (*Deficient*), 0 (*Minimum acceptable performance*), +5 (*Best practice*), 1-4 (*Intermediate performance level*)	BEE=3.0 or more(*Excellent*), BEE=1.5~3.0 (*Very Good*), BEE=1.0~1.5 (*Good*), BEE=0.5~1.0 (*Fairy Poor*), BEE=less than 0.5 (*Poor*)	**NB:**50-74 (*Certified*), 75-84 (*Gold*), 85-89 ($Gold^{plus}$), 90 and above (*Platinum*); **EB:** 55-69 (*Certified*), 70-79 (*Gold*), 80-84 ($Gold^{plus}$), 85 and above (*Platinum*)	Depending on how many common items, and priority items have been satisfied, the participants will be rewarded as three levels: *one star, two stars, three stars*

APPENDIX H: Comparison of GBTs based on criteria of assessment

Name of rating tool	BREEAM	LEED	GREEN STAR	DGNB	SBAT	CASBEE	ZSHG
Criteria for assessment	1.Management 2.Health and Wellbeing 3.Energy 4.Transport 5.Water 6.Materials 7.Waste 8.Land Use, Ecology 9.Pollution 10.Innovation (additional)	1.Sustainable Site 2.Water efficiency 3.Energy and atmos. 4.Mat. & Resource 6.Indoor Environment Quality 7. Design innovation 8.local enviro.	1.Management 2.Indoor Environ. 5.Energy 6.Transportation 7.Water 8.Materials 9.Land use &. Eco. 11innovation	1.Ecological quality 2.Econo. quality 3.Social cultural 4.Technical quality 5.Process quality	1.Environmental 2.Economic 3.Social 4.Education, Health & Safety	Q1: Indoor enviro. LR1: Energy Q2: Quality service LR2: Res. & mat. Q3: Outdoor environ. on site LR3: Off-site enviro	1.Energy, Water, Materials 2.Biodiversity 3.Transport 4.Resource use 5.Management 6.Local economy 7.Services and product 8.Access, health, 9. Education 10.Inclusion, Social, cohesion

APPENDIX I: Publications

Peer reviewed journals

Sichali M., Banda L. J., (2017) Awareness, Attitudes and Perception of Green Building Practices and Principles in the Zambian Construction Industry. *International Journal of Construction Engineering and Management*. doi: 10.5923/j.ijcem.20170605.04

Sichali M., Muya M., Mwiya B., (2020), A Cross-Sectional Study of Utilization of Green Building Rating Tools by Selected Professionals in the Zambian Building Industry. DOI:10.4236/jbcpr.2020.83014 *Journal of Building Construction and Planning Research*, 8(3), 217-235

Sichali M., Muya M., Mwiya B. (2021). An Integrated Green Building Assessment Tool for Low-cost Housing Development in Zambia. *Sustainability in Environment*, ISSN 2470-637X (Print) ISSN 2470-6388 (Online) 6(3), 2021 DOI:10.22158

Peer reviewed conference proceedings

Sichali M., Muya M., Mwiya B., (2017) The Green Building Movement in Zambia. DII-2016 Conference on Infrastructure Development and Investment Strategies for Africa, ISBN 978-0-620-74121-7, September 2017 at Protea Hotel, Livingstone, Zambia.

Sichali M., Muya M., Mwiya B., (2021) Smart Homes in Smart Cities for a Sustainable Urban Climate: The use of urban sustainability tools in Zambia's housing development. ZIA-2021 International Conference on Architecture and urbanism: challenges and opportunities of smart cities, 26 November 2021 at Avani Victoria Falls Resort, Livingstone, Zambia.