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RESEARCH ARTICLE

Green-Building Practices: Reducing Emissions and Enhancing Urban Housing Sustainability in Africa

Kabemba Ngoy Steve[1], Abimbola Windepo[2], Darmarajan Chinasamy[3], Sizolwenkosi Mthethwa[4] and Timothy Gbenga Nubi[5]

[1]Department of Construction Economics and Management, Faculty of Engineering and The Built Environment, University of Cape Town

[1,5]Department of Estate Management, ARUA Center for Urbanization and Habitable Cities, University of Lagos, Lagos, Nigeria

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Corresponding author:
kabembasteve7@gmail.com

ABSTRACT

Through a systematic concept map, this study theoretically explores the effectiveness of green-building practices in reducing carbon emissions and enhancing sustainability in urban housing. The building and construction industry is one of the largest contributors to greenhouse gas emissions globally because of its substantial use of materials and energy, which inevitably results in carbon emissions and waste, thereby worsening the greenhouse effect by causing global temperature rise. The adverse consequences of these practices are amplified as society's resources are depleted through the consumption of non-renewable energy sources, thus contributing to the gradual deterioration of the earth's ecological environment. Importantly, the long lifespan of existing buildings means that the impact of poor building practices in Africa will be felt for decades to come. The researcher conducted a systematic literature review involving peer-reviewed journal articles, conference proceedings, books and relevant industry reports obtained from academic databases such as Scopus, Web of Science and Google Scholar. The review was structured on essential themes surrounding sustainable building practices in urban housing, capable of reducing carbon emissions. The study found that the use of non-renewable energy sources, such as coal, oil, gas and diesel generators which are heavily relied upon for heating, cooling and lighting of buildings lead to high carbon emissions, putting them among the primary drivers of carbon emissions in the construction sector. Numerous studies have highlighted not only challenges but also the effectiveness of green building practices in mitigating carbon emissions and promoting sustainability in urban housing. It was also found that the adoption of green building practices such as energy-efficient design, renewable energy integration and efficient water management can lead to reductions of up to 30% in CO_2 emissions while simultaneously improving indoor air quality and creating a healthier and more comfortable living environment for residents in the African context. Given these findings, the study concludes that inefficient building design and construction practices result in energy-inefficient buildings that undermine efforts to reduce carbon emissions.

Keywords: Green building practices, Carbon emissions reduction, Urban sustainable housing, Energy efficiency

1.0 Introduction

There is no doubt that climate change is a worldwide problem requiring urgent attention. About 40% of the world's energy consumption and carbon dioxide (CO_2) emissions come from the building industry, which is one of the biggest artificial factors contributing to the rise in CO_2 emissions (Chau et al., 2015). In order to

offset the effects on the environment, economy and society, as well as to achieve the Sustainable Development Goals (SDGs), it is crucial to reduce the life cycle of carbon emissions and the energy consumption of buildings (Liu et al., 2022). Adopting green-building techniques is a sustainable strategy that can improve housing sustainability and lower carbon emissions (Khahro et al., 2021). According to Nduka and Ogunsanmi (2015), among other things, green-building practices are about creating sustainable sites, boosting energy and water efficiency, cutting waste and emissions, utilising eco-friendly building materials and enhancing indoor environmental quality more effectively than traditional methods.

The concept of "green building" refers to innovative methods for organising, creating and building structures. Green buildings use engineering and design techniques to minimise the use of non-renewable resources while taking occupant well-being and the environment into consideration (Keysar & Pearce, 2007). Reducing carbon emissions, protecting natural resources and improving occupant quality of life are the main objectives of these approaches. The concept of "green building" was developed to lessen a structure's lifetime environmental impact. According to Liu et al. (2022), low carbon emissions, energy savings and financial advantages throughout the entire cost cycle make green buildings more valuable commercially than regular ones. In order to reduce the negative impact of buildings on the environment and maximise their positive social and economic effects, green buildings have become inevitable in modern society (Charoenkit & Kumar, 2014).

Since one of the main factors influencing a country's socio-economic progress is housing, governments tend to enact policies aimed at the efficient provision of housing (Adabre et al., 2021). In order to achieve sustainability in the construction of low-income housing, reducing carbon dioxide emissions while taking a building's life cycle and the climate into account has emerged as a significant environmental concern (Habitat, 2011). Thus, architects, planners and developers need tools for assessing the environmental performance of housing systems during planning and designing process in order to ensure that the reduction of carbon emissions is taken into account in urban housing design. Charoenkit and Kumar (2014) observed that while a number of measures have been developed for the sustainability of urban development projects, there is a lack of critical evaluation of the efficacy of addressing carbon emissions reduction, climate vulnerability and the application of such tools to low-income housing, particularly in developing countries.

A major obstacle to the building industry's attainment of sustainability is the rising CO_2 emissions caused by the use of non-sustainable energy sources in building design, construction and operation. A large amount of the energy used in the building industry comes from fossil fuels, which contribute significantly to greenhouse gas emissions worldwide. As of today, only a small portion of the energy used in buildings comes from sustainable and renewable sources, with serious implications for the environment. Indeed, there is a substantial information vacuum about the efficacy and usability of green construction approaches in diverse housing environments. This makes it more difficult to create and implement sustainable solutions, which are further hampered by insufficient technology and a lack of government policies. Therefore, it is necessary to determine the best green-building techniques for lowering carbon emissions and improving sustainability in various housing contexts, while also considering obstacles to their adoption and the possible solutions. Developing successful strategies to reduce carbon emissions and advance sustainability in the housing sector also heavily depends on determining how cost-effective it is to implement these practices, how they affect the value of housing properties and how they affect the health and well-being of occupants.

According to Ahmed Ali et al. (2020), existing research reveals constraints resulting from insufficient government regulations and technology, as well as a deficit in knowledge regarding the efficacy and applicability of green construction methods in various housing scenarios. Thus, by identifying practical methods for lowering carbon emissions and improving housing sustainability, this study seeks to close these gaps and advance understanding of green-building techniques.

2.0 Methodology

2.1 Research Approach

A qualitative study, this work adopts the Systematic Literature Review (SLR) approach, which is deemed the most appropriate option since the research aims to

explore, interpret and synthesise a complex phenomenon: the interplay of green-building practices, carbon emissions and sustainability in a specific context (Snyder, 2019). This method allows for the thematic organisation of textual data from diverse sources, facilitating a deep understanding behind the effectiveness and challenges of these practices, rather than quantifying their frequency (Creswell & Poth, 2016). The outcome is a systematic concept map that synthesises these themes into a coherent theoretical framework.

3.0 Data Collection

The literature search was performed across three academic databases: Scopus, Web of Science and Google Scholar. The search strategy combined key concepts from the research objective, viz: "urban housing" AND "Africa", "green building" and "carbon emissions" using the "AND" Boolean operator. The search was limited to publications from 2013 to 2023 to focus on contemporary studies. To finalise the literature base for analysis, the screening process was conducted in two phases: an initial screening of titles and abstracts for relevance, followed by a full-text screening of shortlisted articles against predefined inclusion criteria such as a focus on African urban housing and a discussion of green practices and carbon emissions.

3.1 Data Analysis and Concept Mapping

The selected literature was reorganised thematically, following a systematic process of reading them and identifying recurring patterns and themes from the textual data. This process began with familiarisation, where the full texts were reviewed to gain deep familiarity and identify initial findings while capturing key concepts, practices, outcomes and challenges. These findings were then collated and grouped into coherent themes during the theme development stage, which structured the final results around core areas such as emission drivers, key green interventions, documented outcomes and contextual challenges in Africa. The final stage involved synthesising these themes and their interrelationships to construct a systematic concept map, providing a visual framework that logically represents the narrative from the literature by illustrating the pathway from problem drivers through effective interventions to the resulting sustainability outcomes.

4.0 Findings

4.1 Green-Building Practices

Energy-Efficient Design

The desire to reduce the environmental impact of buildings and the rising energy demands make energy-efficient designs essential. Important design factors, e.g., a building's form and aesthetics, which are heavily influenced by the form, cannot be disregarded in order to create an energy-efficient structure. In actuality, the energy performance can be greatly impacted by the building form (Tian et al., 2018). A significant amount of the world's energy consumption and greenhouse gas emissions are caused by the construction and maintenance of buildings. Tian et al. (2018) further observed that in order to lower energy consumption and advance sustainability it became necessary to implement passive building design solutions. Because building form can have a considerable impact on energy performance, passive design solutions that optimise the building envelope are essential (Tian et al., 2018). In this regard the most important elements are as follows:

- Walls: Exterior walls are important to protect the building from external environmental effects. The most efficient option found was concrete and brick walls based on their life cycle.
- Roofing: For roofs, the depth of insulation was the most significant factor when calculating energy estimations of roof construction (Kim et al., 2011).
- Windows: Glazing is a critical factor, as the relatively low insulation levels afforded by windows will have an impact on the internal thermal performance. While single glazing windows are said to be more efficient as they provide more light (Fan and Xia, 2018), the optimal proportion must be determined.
- Facades: As an environmental mediator, creative solutions like kinetic facades have been shown to maintain 38–55% of the suggested lighting levels (Kensek & Hansanuwat, 2011). In a similar vein, Chan et al. (2009) suggested using double-skin facades as a novel strategy for a buildings' sustainable energy performance.

Renewable Energy Integration

Integrating on-site renewable energy is essential for decarbonizing building operations. This process has been internationally recognised to promote innovative

approaches for the mitigation of carbon dioxide (CO_2) emissions due to energy consumption associated with building construction and operation (GhaffarianHoseini et al., 2013). Solar connectors have been used as a main component of green progressions (GhaffarianHoseini et al., 2013). The range of technologies is versatile, as shown in Table 1.

Table 1: Versatile Types of Renewable Energy

Renewable energy	Description and Benefits	Use
Active energy	Solar	Convert solar energy into another more useful form of energy. This would normally be a conversion to heat or electrical energy. Inside a building this energy would be used for heating, cooling or off-setting other energy use or costs. The basic benefit is that controls can be used to maximise its effectiveness. Photovoltaic solar panels are in this group.
Passive energy	Solar	In passive solar building design, windows, walls and floors are made to collect, store and distribute solar energy in the form of heat when it is cold and reject solar heat when it is hot. The key to designing a passive solar building is taking advantage of the local climate.
Wind energy		Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity, windmills for mechanical power, wind pumps for water pumping or drainage.
Geothermal energy		Geothermal energy is thermal energy generated and stored in the Earth.
Fuel cell		A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. Hydrogen is the most common fuel.

***Source**:* Qaemi & Heravi (2012)

Integrated solutions work quite well. For example, Kumar and Kaushik (2005) suggested using green roofs that are combined with solar shading devices. A study by Jaffal et al. (2012) provides more evidence that green roofs improve indoor thermal comfort and a building's energy efficiency. Achieving zero energy building design is the ultimate goal for some projects, and architects and multidisciplinary academics have made it a top priority. Important components include solar hot water systems, lighting and space heating (Wang et al., 2009). Frameworks like Energy Performance Contracting (EPC), which is impacted by a number of operational parameters, can guide the implementation of such projects.

Table 2: Operative Factors for EPC towards Sustainable Developments

Groups	Factors
External factors	Economic environment Social environment Policy support Nature environment Available technology
Project-self factors	Hotel operation status Project complexity Building age

Groups	Factors
	Site and location limitation Tourism season and operating time limitation
Leadership and team factors	Clients' awareness of the EPC Organising skill of leader Team members' technical background Communication skill
Sustainable development factors	Clients' and ESCOs' awareness of the sustainable development (SD) theory Sustainable development strategy planning Control mechanism of sustainable development strategy
Financing factors	Available financial market Awareness of financing institute to EPC Credit of ESCOs and clients Project financial status
Contracting factors	Saving share Task and risk allocation
Partnership factors	Trust Effective coordination
Project process factors	Develop appropriate organization structure Project objectives control mechanism Accurate M&V

***Source**:* Xu et al. (2011)

Efficient Water Management

The energy cost of providing and treating water is decreased via water efficiency. Reducing water use and minimising wastewater production are the goals (Christidou et al., 2014). Reusing rainwater and greywater is one strategy, as is installing efficient water-saving home equipment (low-flow toilets, showers, faucets and washing machines) (Christidou et al., 2014). This is important because 60–75% of household wastewater (or freshwater usage) is made up of greywater (Christidou et al., 2014). Furthermore, on-site water conservation and water harvesting are crucial practices because the construction industry is one of the sectors using the most water, at around 20% (Sheth, 2017).

Material Selection and Life Cycle Assessment

The life cycle assessment refers to the sustainable methodology used to analyse the technical, economic and environmental consequences of decisions made throughout a product's entire life cycle (Jamwal et al., 2021). The primary concern of LCA is to evaluate the possible environmental effects of all incoming and outgoing elements throughout the life cycle of a product, starting from the procurement of raw materials through production and utilisation to maintenance, and extending to the product's end-of-life stage (Sartori et al., 2021). Several rating systems or tools have been created to support the advancement of environmentally friendly building practices in numerous countries (Geng et al., 2019). Examples include Leadership in Energy and Environmental Design (LEED) in the United States and the British Environmental Assessment Method (BREEAM) in the United Kingdom.

Indoor Environmental Quality Enhancement

Indoor environmental quality (IEQ) encompasses the various environmental elements that impact the physical health and overall welfare of individuals occupying a building (Bluyssen, 2009), with regard to the general comfort of a building's interior and the well-being of its inhabitants. In the African context, where urban populations are rapidly growing, there is a substantial body of evidence suggesting that enhanced indoor environments result in greater occupant contentment, productivity and overall well-being (Thayer et al., 2010). Studies in the United Kingdom context found a huge waste of energy consumption during unoccupied days at weekends. It was also found that night-time electricity baseline loads have been growing at an approximate annual rate of 8%, although there are significant differences in this trend among different

building types (Brown et al., 2010). This is a critical consideration for African cities facing energy poverty and unreliable supply.

Li et al. (2014) showed that in countries such as the US, the UK and China there was a tendency for reduced energy usage in small buildings, although the relationship was not entirely consistent. In comparison to other nations, Hong Kong (China) had the highest proportion of energy consumption attributed to heating, ventilation and air-conditioning (HVAC) systems (Jing et al., 2017). For many African nations, the priority is often on passive cooling rather than high-energy HVAC, while in China recent studies indicate a decrease in energy consumption as policies came into force on the construction of green buildings (Brown et al., 2010). Similar studies further show that green buildings have the potential to generally conserve energy. However, additional research is required to address the performance disparity between the operational phase and the initial design phase, a gap that is even more pronounced in African housing studies.

Furthermore, Indoor Environmental Quality (IEQ) is one of the significant performance categories for evaluating a green building and may be considered as the key indicator of benefits from green buildings. However, certain physical and non-physical factors affect IEQ and occupant satisfaction (see Figure 1). Choi and Moon (2017) observe that the non-physical factors are the most challenging to quantify. The diagram below shows examples of the two factors of IEQ.

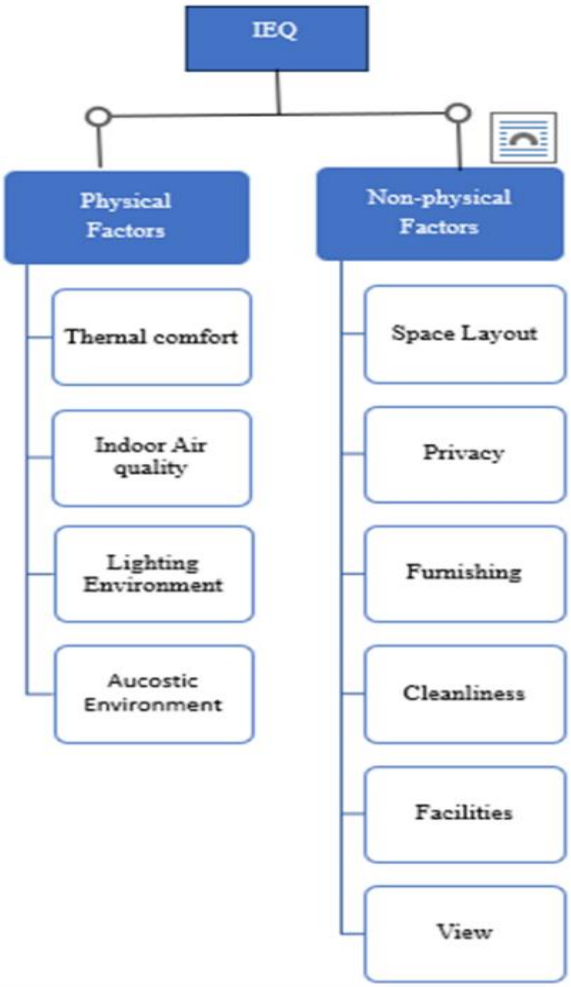


Figure 1: IEQ factors

Source: Choi & Moon (2017)

To ensure further satisfaction of the occupants based on the IEQ, the required energy has to meet the needs of the building. For example, the heating energy consumption in Austria, Belgium, Northern China, and Norway are similar, whereas there is a notable difference in heating energy consumption in France (Yoshino et al., 2017). These differences show that the building needs for energy in different countries are not the same, hence the need for region-specific IEQ standards in Africa, where climatic and cultural needs differ greatly. In the US the indoor air temperature of green buildings turned out to be relatively stable across different seasons. In China the indoor air temperature varied across the seasons (Geng et al., 2019). Their study further showed that the average ratings for occupant satisfaction with IEQ in green buildings mostly exceeded 0, indicating general contentment with IEQ factors within these buildings. Demonstrating similar occupant satisfaction in African green buildings is vital for promoting their adoption.

4.2 Evaluation of Carbon Emissions Reduction

Quantifying the Impact of Green Building Practices

Measuring the social, economic and environmental advantages derivable from operationalising sustainable methods is part of quantifying the effects of green-building approaches. Embodied carbon, which measures the quantity of greenhouse gases released during the phases of raw material extraction, production, transportation, construction, repair, maintenance and material fabrication, can be used to evaluate the environmental impact of the construction industry (Jayasinghe et al., 2022).

4.3 Enhancing Sustainability in Housing

Life Cycle Assessment and Sustainable Development

In 2018, the global construction sector accounted for a significant share of carbon emissions, with 2.72 billion tCO_2 arising from building material production and 2.11 billion tCO_2 from construction operations (Fang et al., 2018). While these figures are global and should not be directly attributed to Africa, they provide an important warning for regions undergoing rapid urban growth. In the African context, where urbanisation and housing demands are accelerating, continuing with similarly unsustainable construction practices could increase the sector's future carbon burden. This highlights the need for the early adoption of green-building practices to help avoid emissions-intensive development pathways.

For the assessment of carbon emissions two methods are used: whole-process and whole-life analyses. Whole-process analysis involves calculating emissions from building material production, construction, operation and demolition each year (Kavgic et al., 2010). Whole-life calculation accounts for a building's emissions from design, construction, use and end-of-life stages. About 20% of emissions come from building material production, while 80% stems from building operations in the whole-life calculation (Moncaster et al., 2019). In Africa, where operational energy often relies on carbon-intensive diesel generators, this 80% operational share could be even higher, highlighting a critical intervention point. Current efforts to control building emissions focusing on improving energy efficiency in building operations, which in turn aims to decrease the operational phase's proportion of total emissions (Dekkiche & Taileb, 2016).

Life Cycle Assessment (LCA) is a widely used method for environmental impact assessment, guided by ISO standards. ISO 14067 assesses product carbon footprints, while ISO 21930 evaluates the environmental impact of construction projects (Dekkiche & Taileb, 2016). Various countries' standards, such as LEED and BREEAM, incorporate LCA-based assessments for project scoring. In China, the Assessment Standard for Green Buildings was revised in 2019 to require LCA-based calculations for building carbon emissions at both the design and operation stages (Dekkiche & Taileb, 2016). While the application of such LCA-based standards in Africa is still nascent, it remains crucial for quantifying the true environmental cost of the continent's built environment.

Green-building evaluation requirements and corresponding design measures can lower carbon emissions directly or indirectly. These measures include energy-efficient systems, alternative materials and sustainable design strategies. The research shows that green buildings have lower

operational and embodied carbon emissions compared to conventional buildings (Khasreen et al., 2009). This proven reduction is a powerful rationale for prioritizing green-building codes and incentives across African nations to steer future development onto a more sustainable path.

Assessing Environmental Performance Matrices

The evaluation of environmental performance indicators highlights the significance of housing as a fundamental requirement that can improve quality of life. It describes the public sector's commitment to fostering an effective and sustainable housing sector in order to guarantee access to high-quality, reasonably priced homes. In Africa, where housing stocks are being overtaken by increasing urbanisation, this problem is particularly serious. Nonetheless, some cheap housing developments frequently overlook social, economic and environmental aspects and do not adhere to sustainability standards (Sivam & Karuppannan, 2008). Large-scale housing projects in Africa frequently fall into this trap.

In Malaysia, low- to medium-income residents want inexpensive housing but the cost of homes has been steadily growing in the country, putting them beyond the reach of many. This predicament is similar to the housing affordability crisis that exists in many African cities. From an economic, sociopsychological and environmental perspective, incorporating sustainability elements into housing building is essential (Ouyang, 2011). However, there is no match between the imperatives of sustainable development and affordable housing approaches because it is thought that low- to middle-class households may not be able to buy sustainable housing (Sharifzai et al., 2016). One of the main obstacles to the adoption of green buildings in Africa is the perceived trade-off between price and sustainability. Strategies for integrated affordable and sustainable housing will need to be developed in order to address these issues as faced by Malaysians, even though not much research has been done on the subject. In the heterogeneous and rapidly urbanising setting of African countries, this research vacuum is even more noticeable.

According to Sivam and Karuppannan (2008), housing expenses need not surpass thirty percent of a household's income in order to be considered affordable. As a component of sustainable development, sustainable housing should be practicable, economically feasible, socially acceptable and environmentally benign. The goal of integrating affordable and sustainable housing is to offer reasonably priced homes with emphasis on sustainability, healthy living and safety. This connection is essential for robust urban growth in Africa, not a luxury.

Economic and societal growth may suffer from a shortage of sustainable and reasonably priced housing (Li & Li, 2006). Economic performance and social sustainability may be impacted by rising housing costs, which may have an effect on life events such as marriage and childbirth (Song, 2010). The high purchase rates of sustainable housing in Malaysia make it difficult for low- to middle-class groups to access the housing market (Jamaludin et al., 2018). Similarly, most people in Africa are unable to afford sustainable technologies owing to their high initial cost.

Thus, the Malaysians' experience highlights the pressing need to integrate sustainable practices and affordable housing. In Africa, where the urban population is expected to increase considerably over the next few decades, the need for this integration is even more pressing. These housing developments are currently not widely implemented, with a number of issues needing urgent resolution. In order to enhance the population's well-being and standard of living, sustainable development should go beyond economic concerns (William & Dair, 2007). In order to accomplish this, stakeholders must be informed about the long-term advantages of affordable and sustainable housing. To promote more sustained efforts, public authorities could provide training, refunds and incentives. By enforcing stringent laws and regulations to guarantee the adoption of sustainable practices, the government can play a major role. For African governments to guide the construction industry toward sustainability, several policy initiatives are essential. In order to improve the standard of living in sustainable communities, integrating affordable and sustainable housing ultimately requires cooperation from all pertinent stakeholders. Both

the future of African cities and Malaysia's building sector depend on the development of integrated affordable and sustainable housing policies (Abidin, 2010).

Economic Viability and Long-term Benefits

This is a critical consideration for Africa, which has the world's fastest urban growth rate. Green buildings aim to mitigate negative impacts on the environment and resources while enhancing positive effects throughout the life cycle of a building (Darko & Chan, 2016; Council, 2013; Zuo & Zhao, 2014). The study notes that while green building investments can be seen as profitable from the building life cycle perspective, economic viability remains controversial for developers and occupants (Jakob, 2006). This controversy is particularly acute in African markets, where access to capital is limited and short-term costs often dominate decision-making.

The researchers identified three categories of barriers that limit economic viability from the perspective of developers and occupants, all of which are highly relevant to the African context:

(a) Behavioural problems: Developers tend to overestimate costs and occupants may not pay enough attention to energy efficiency, leading to misconceptions about the true benefits of green buildings (Bartlett & Howard, 2000). In Africa, where the concept of green building is relatively new, these misconceptions can be a major barrier to demand.
(b) Information asymmetry: Buyers may hesitate to choose green buildings because of a lack of information, which can lead to a cost-benefit mismatch for developers and hinder the adoption of green practices (Bartlett & Howard, 2000). The lack of localized data on green building performance in Africa complicates this information gap.
(c) Energy pricing and contract structure: Existing energy pricing and contract structures may prevent occupants from enjoying cost savings from energy efficiency, which will further discourage the adoption of green buildings (Bartlett & Howard, 2000). In many African countries, energy subsidies can distort the economic argument for efficiency, while rental agreements often separate the tenant from utility savings.

This research utilised Life Cycle Assessment (LCA) to evaluate the sustainability of buildings throughout their life cycle, based on economic valuation that considers the entire life cycle of green buildings, including design, construction, operation and demolition. The study also examines the incremental costs of green buildings, which have been perceived to be more expensive than traditional building methods, particularly during the construction stage. Overcoming this perception of high upfront cost is a fundamental challenge for green-building advocates across Africa.

Overall, the study notes the importance of economic viability in promoting the adoption of green buildings and suggests that a holistic approach involving various stakeholders, including governments, developers and occupants, is crucial for achieving a more sustainable built environment. For Africa, such a holistic, multi-stakeholder approach is not just beneficial but essential to align economic imperatives with sustainable development goals.

Developed Concept Map

The systematic literature review yielded a systematic concept map, as presented in Figure 2, which synthesises the key themes and their interrelationships. The findings are structured to present a logical narrative, beginning with the identified drivers of carbon emissions, moving through the key green-building interventions, detailing their multifaceted benefits and concluding with the critical challenges and opportunities for implementation, particularly in the African context.

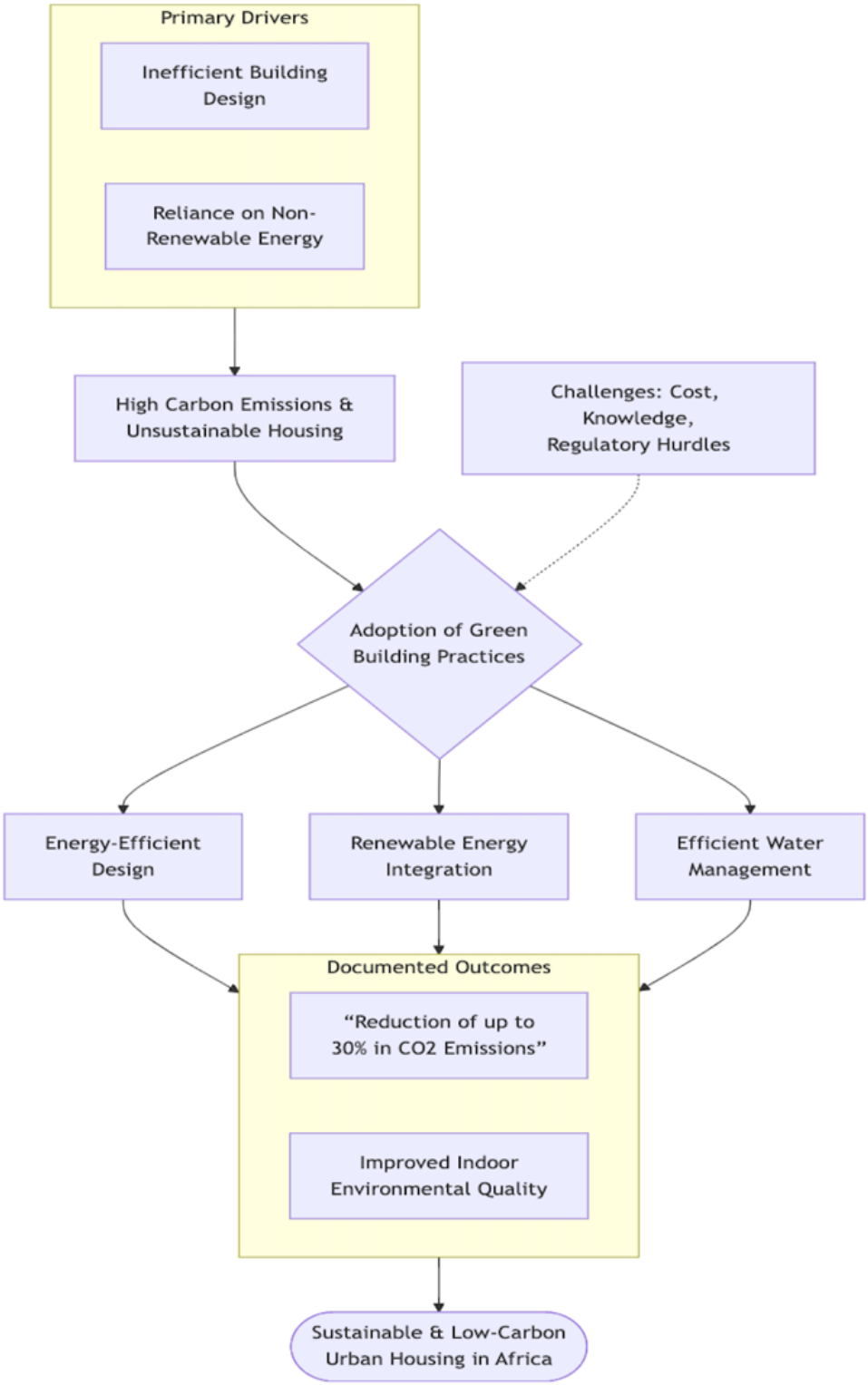


Figure 2: Systematic Concept Map for Reducing Emissions and Enhancing Urban Housing Sustainability in Africa

Source: Authors' design, 2024

5.0 Conclusion

This literature review highlights the significance of green-building practices in reducing carbon emissions and enhancing sustainability in housing. Applied to the African context, the findings underscore the importance of energy-efficient design, renewable energy integration, efficient water management, appropriate material selection and indoor environmental quality enhancement. While the benefits of green-building practices are well-documented, challenges such as regulatory barriers, financial implications and public awareness need to be addressed for widespread adoption across the continent. The review emphasizes the need for policy support, economic viability and collaboration among stakeholders to realise the full potential of green-building practices in achieving sustainable and low-carbon housing in Africa's rapidly growing cities.

By examining a diverse range of sources, this literature review offers a comprehensive evaluation of green-building practices and their role in mitigating carbon emissions and promoting sustainability in housing. It serves as a valuable resource for researchers, policymakers and industry professionals in Africa seeking to enhance their understanding of effective strategies for green and sustainable housing development tailored to the region's unique climatic, economic and social conditions.

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