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Original Article

Comparing Between the Awareness and Adoption of Sustainable Construction Practices in Kenya

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ABSTRACT

Despite the numerous advantages of adopting sustainable construction practices, the approach is reportedly not being adopted by Kenyan construction industry stakeholders as would have been expected. This research sought to evaluate the extent of awareness and adoption of sustainable construction practices. The research adopted a survey design using questionnaires with closed-ended and open-ended questions. A sample size of 217 respondents was drawn from Architectural firms, Quantity Surveying firms, Engineering firms (civil, electrical & mechanical), Construction Management firms, Construction Project Managers, Building Contractors, Property Developers, and Real Estate Agents. A response rate of 83% was achieved. The study established a high level of awareness of 79.0% and described it as 'a very good understanding' based on the scale used. The overall extent of adoption of sustainable construction practices in Kenya was estimated to be 72.3%. Further, the study established a statistically significant moderate positive relationship between the extent of awareness and that of adopting sustainable construction practices. It was concluded that though the levels of awareness and adoption of sustainable construction practices in Kenya are now relatively higher compared to previous years, there still exist barriers to achieving 100% awareness and adoption. One of the recommendations made by this research is that the government needs to formulate an elaborate legal and regulatory framework for sustainable construction. Such a framework should provide clear implementation guidelines including the institutional framework, financial incentives, and penalties associated with sustainability in the construction sector.

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INTRODUCTION

The construction industry is key to the successful realization of sustainable development. This is mainly attributed to the centrality of its operations that affects the social, economic, and environmental facets of society . Socio-economically, it affects the country in the following ways; (i) It puts up the infrastructural and productive foundation in the form of housing, transport networks, and industrial bases, which then convert this into economic success, social equalization, and higher standards of living for the citizens , (ii) It is a major contributor to the Gross Domestic Product (GDP). This is usually higher in proportion in developing countries like Kenya as compared to the developed countries , (iii) It creates over 110 million employment opportunities for people all over the world. In developed nations, the industry is labour-intensive and therefore, a huge percentage of citizens are employed as workers in construction-related projects (Ganiyu, Fapohunda, & Haldenwang, 2015; Huang & Hsu, 2011), and (iv) Its widespread nature across the country creates a vital opportunity in the transfer of sustainable technology and creation of awareness as this will result in widespread coverage within a short time.

The construction industry is highly extractive and uses enormous volumes of materials sourced from the environment. Worldwide, the construction industry produces a tremendous amount of construction and demolition debris every year, with one recent study estimating the production of such waste to reach 2.2 billion tons by 2025 . The construction industry accounts for a global 40% of energy consumption, 40% of all raw materials, 25% of all timber products, 16% of water consumption, 40% of extracted natural endowments, 25% of carbon dioxide emissions, and generation of 45-65% of waste deposited in landfills .

Despite the numerous advantages of adopting sustainable construction practices, the approach is not being adopted by Kenyan construction industry stakeholders as would have been expected. This is evident by the insignificant number of projects that have adopted sustainable technologies amidst many building and infrastructural projects completed in the recent past.

There has been an effort by the government to formulate regulations and policies, including the National Environmental Policy 2012, the Physical Planning Act, the National Building Regulations 2022, the Energy Act 2019, the Green Economy Strategy and Implementation Plan, the Waste Management Regulations 2006, Environmental Management and Coordination Act 2015, ban on single-use plastic in 2017, the Occupational Safety and Health Act (OSHA) 2007 and the Extended Producer responsibility regulations 2021. In addition, the government has established regulatory bodies like the National Environmental Authority (NEMA) and National Construction Authority (NCA) to oversee and regulate the construction industry and ensure construction activities do not have negative impacts on the health and well-being of people and the natural environment.

The private sector has also been active in innovating technologies and materials that are eco-friendly and efficient like stabilized soil blocks/bricks, products from recycled content, energy-efficient fixtures, solar-powered products, sustainably harvested timber, light gauge steel and many other resource-efficient products. However, apart from solar products, consumption of the so-called alternative building materials and technologies (ABMTs) has reportedly been on the lower side as people still use conventional approaches to constructs, decades after these products were introduced in the market. Therefore, this research sought to evaluate the extent of awareness and adoption of sustainable

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construction practices in construction projects in Kenya.

LITERATURE REVIEW

Concept of Sustainable Construction

The construction industry has over time earned a reputation for not being friendly to the environment. This is based on what has been consistently observed in how building structures are put up with little or no regard for the most critical environmental concerns. There has been a lot of concern from the scholarly world and green movements, pertaining to persistent destruction and the massive impact of the industry on natural ecosystems. As such, sustainable construction was birthed to address some of the critical issues and give guidance on how sustainability as a practice can be incorporated into construction design and operations.

Sustainable construction can be defined as the creation and responsible management of a healthy built environment based on resource-efficient and ecological principles . It is a holistic process aiming to restore and maintain harmony between the natural and the built environments and create settlements that affirm human dignity and encourage economic equity. This definition goes further than the environmental impacts of construction and says something about the economic and social dimensions of sustainability.

As a concept, sustainable construction has been applied variedly in different countries. There has been a tremendous effort in achieving sustainable construction in developed countries as opposed to developing countries. It is this varied application that has led to varied definitions of sustainable construction, especially in its scope and conceptualization. Sustainable construction can be best described as a tenet of sustainable development . Normally, sustainable construction is looked at in three dimensions; environmental, economic, and social dimensions. However, some literature has added more dimensions, including technological, cultural, and community sustainability . Environmental sustainability, which is the focus of this study encompasses renewable resources in preference to non-renewable resources, maximizing resource reuse and/or recycling, and minimizing air, land, and water pollution at the local and global levels.

According to Sourani and Sohail (2005), sustainable construction is the set of processes by which a profitable and competitive industry delivers built assets (buildings, structures, supporting infrastructure, and their immediate surrounding) which:

- Enhance the quality of life and offer customer satisfaction
- Offer flexibility and the potential to cater to user changes in the future
- Provide and support desirable natural and social environments
- Maximize efficient use of resources

In the current dispensation, sustainability has become a popular theme as efforts are made to ease pressure on natural resources, which are getting depleted with time. The increase in human population and economic growth has led to the over-exploitation of the earth's natural endowment. As a result, sustainable construction has become imperative in ensuring the proper utilization of natural resources in all construction-related undertakings

The International Council for Research and Innovation in Building and Construction (CIB) defines sustainable construction as 'the sustainable production, use, maintenance, demolition, and reuse of buildings and construction or their components' .

According to Du Plessis (2007), no definition of sustainable construction is fully satisfactory. However, all these definitions highlight three basic elements of sustainable construction namely;

- It calls for a wider interpretation of construction as a foundation to critical processes, which involve more participants

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than those conventionally recognized as comprising the construction industry.

- It emphasizes environmental conservation and value addition to the quality of life at an individual and community level.
- It accepts and adopts not only the technological but also non-technical features that relate to socio-economic sustainability.

Basic Features of Green Building

"Green" buildings are high-performance structures that also meet certain standards for reducing natural resource consumption . Green buildings are specifically designed to reduce the negative effects on the environment caused by construction, while also ensuring that the people who live or work in these buildings have a healthy and comfortable living environment.

The following are some of the characteristics of "green" buildings; (i) Efficient management of energy and waste resources, (ii) Management of material resources and waste, (iii) Restoration and protection of environmental quality, (iv) Enhancement and protection of health and poor environmental quality, (v) Reinforcement of natural systems, (vi) Analysis of the lifecycle costs and benefits of materials and methods, and (vii) Integration of the design decision-making process .

Sustainable Sites

To ensure the sustainability of sites, the following factors need to be considered; (i) Careful site Selection, (ii) Controlling development density, (iii) Prioritizing brownfield redevelopment, (iv) Creating alternative transportation, (v) Reducing disturbance on-site through protecting or restoring open spaces and creating a development footprint, (vi) Managing storm water by controlling the rate and quantity of flow as well as ensuring treatment to make it unharmful to the environment, (vii) Preventing the heat island effect through the adoption of green roofs, and (viii) Reducing light pollution which comprises urban sky glow, light trespass, glare, and clutter .

Energy and Atmosphere

Lighting accounts for 4% of energy consumption in residential houses and up to 30% in commercial buildings . Light control and smart meters are being promoted as good practices in a bid to reduce energy consumption and promote efficiency. The adoption of LED lighting devices helps save energy and help reduce energy demand . In Kenya, the government through Kenya Power and Lighting Company and the Energy Regulatory Commission (ERC) has been engaging in campaigns to sensitize the public on available energy-saving options. Among other key things, the replacement of incandescent lamps with Compact Fluorescent Lamps (CFLs), installation of solar water heating, solar-powered street lighting, and free long-term loans to companies investing in local energy generation have been adopted by the government to encourage energy-saving.

The following factors are worth considering to achieve efficiency in energy consumption and pollution free atmosphere: (i) Fundamental building system commissioning, (ii) Minimum energy performance, (iii) Reducing emission of CFCs in HVAC & R Equipment, (iv) Optimizing energy efficiency through adoption of appropriate technologies, (v) Adopting renewable energy technologies, (vi) Additional commissioning, (vii) Protecting the ozone layer, (viii) Measurement and verification of energy consumption and level of emissions by systems, and (ix) Installation of green power in buildings and industries like wind energy harvesting and photovoltaic roof systems in buildings .

Indoor Environmental Quality

It is an important consideration as it determines the type of technologies to be installed and the level of emissions released passively by such technologies. According to Darko & Chan (2016), several factors need to be considered to achieve this. The following are some of the important factors; (i) Minimum AIQ (Indoor Air Quality), (ii) Environmental tobacco smoke control, (iii) Carbon Dioxide Monitoring, (iv) Ventilation Effectiveness, (v) Construction of IAQ

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Management Plan during construction and before occupancy, (vi) Thermal comfort through compliance and installation of permanent monitoring system, and (vii) Daylight and views (Daylighting in 75% of spaces and views for 90% of spaces).

Water Efficiency

Proper adoption and implementation of water-efficient appliances and fixtures can significantly lower the water consumption rate to 30%. According to studies, simple solutions such as the installation of feedback gadgets and timers can be instrumental in keeping track of water used hence reducing consumption . In addition, such techniques as rainwater harvesting, water recycling, and sewer mining can be useful in reducing water consumption in commercial and residential buildings . Groundwater recharge by adopting pervious pavement would go a long way in ensuring water efficiency, especially in urban areas.

The installation of water-efficient fittings and devices in offices, residential blocks, and hotels can lead to significant savings in the utilization of water . Areas that offer such opportunities include bathrooms, laundries, and kitchens. Several approaches can be used to achieve this, including designing and implementing water-efficient landscaping requiring no irrigation, adopting wastewater recycling technologies, and approaches that aim at reducing water consumption like waterless urinals and toilets.

In conclusion, Ezilondo and Lofthouse (2010) point out that the reduction of water consumption has to be accompanied by a change in user behavior and the adoption of approaches that give consideration to the various water-related activities. This calls for careful consideration and incorporation of cultural and social backgrounds, alongside financial and technological accessibility when formulating and implementing policies and campaigns focused on promoting water efficiency.

Materials and Resource Efficiency

According to the World Watch Institute, building construction consumes about 40% of raw stone, gravel, and sand globally annually. It also accounts for 25% of wood consumption, 40% of energy, and 16% of water consumed annually. Therefore, selecting environmentally friendly materials is one of the approaches to improving the environmental performance of a building. However, this has to be achieved in balance with the economic performance of using such materials . Green building provides an opportunity to overcome some of the challenges emanating from material scarcity and building performance. Previous research suggests that the following factors need to be carefully considered: (i) Storage and collection of recyclables, (ii) Building reuse; maintaining part or all existing walls, floor and roof and maintaining 100% of the building skeleton and 50% of non-structural elements of a building, (iii) Construction waste management by diverting wastes from landfills through reuse and recycling, (iv) Using recycling content in construction processes, (v) Using regional or local materials; extracted and/or manufactured regionally, and (vi) Using rapidly renewable materials like wood and bamboo for construction.

Literature Gap

There is a notable gap between the awareness of sustainable construction practices and their adoption in Kenya. While several studies have attempted to highlight the importance of sustainable practices (DuPlessis, 2005; Ihuah, Kakulu, & Eaton, 2014), often they do not deeply delve into why awareness does not translate into adoption. There is also limited empirical data on the subject. Previous studies (Serpell, Kort, & Vera, 2013; Ofori, Aigbavboa, & Ansah, 2015) have primarily focused on either awareness or adoption, but few provide a comparative analysis that links the two. This therefore presents an opportunity to explore the factors that contribute to this discrepancy. It creates the need for a comprehensive analysis that connects awareness and adoption among various stakeholders in the Kenyan construction industry including the government, contractors, architects, and clients among others.

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METHODOLOGY

The research adopted a survey design using questionnaires administered using Kobo Toolbox. This approach has been successfully used in several related studies in the past, including Brooks & Rich (2016) in London; Ametepey, Aigbavboa, & Ansah (2015) in Ghana; Wilson & Rezgui (2013) in the UK; Serpell, Kort, & Vera (2013) in Chile; Hakkinen & Belloni (2011) in Finland and Ahn, Pearce, Wang, & Wang (2013) in the USA.

The research selected a population with a better understanding of sustainable construction practices and those that are directly involved in the conceptualization, implementation and operationalization of building projects. These stakeholders included built environment professionals, building contractors, developers and property managers. Therefore, the population for this study was drawn from firms registered by the various accreditation and membership bodies. Accreditation bodies included the Board of Registration for Architects and Quantity Surveyors (BORAQS), Engineers Board of Kenya (EBK) and the National Construction Authority (NCA). Professional bodies included the Kenya Property Developers Association (KPDA), Institution of Construction Project Managers of Kenya (ICPMK) and Association of Construction Managers of Kenya (ACMK). The total population from these various strata was established to be 1,153. The following formula from Kothari (2004) demonstrates how the study sample size was estimated from the target population.

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + (z^2 \cdot p \cdot q)} = \frac{1.96^2 \times 0.5 \times 0.5 \times 1153}{0.06^2(1153-1) + (1.96^2 \times 0.5 \times 0.5)} = 217$$

Where:

n = size of sample

N = size of population (1,153)

z = standard variate at a given confidence level (This study used the standard normal deviate usually set at 1.96 which corresponds to a 95% confidence level)

e = acceptable error (An acceptable error margin of 6% or 0.06 will be used for this study)

p = proportion of the target population estimated to have a particular characteristic.

(Since there is no reasonable estimate, 50% or 0.5 will be used)

q = (1 – p)

RESULTS AND DISCUSSION

Awareness of Sustainable Construction Practices

The first objective of the study was to determine the level of awareness of sustainable construction practices among construction industry stakeholders in Kenya. This was broken down into five categories and measured based on a Likert scale of 1-5. The results presented in Table 1 indicate a high level of awareness across all categories of sustainable construction practices with the means ranging from 3.66 to 4.08. The overall mean was calculated to be 3.95 (79%) and described as ‘a very good understanding’ based on the scale used. This is an indication that construction industry stakeholders in Kenya are generally aware of the existence of these practices.

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Table 1: Awareness of sustainable construction practices

Sustainable construction practice	N	Mean	Std. Dev	Rank
Water Efficiency	180	3.92	0.936	4
Energy Efficiency in buildings	180	4.06	0.876	2
Use of Sustainable Materials	180	3.66	1.015	5
Sustainable Site practices	180	4.08	0.918	1
Indoor Environmental Quality	180	4.03	0.997	3

Source (Fieldwork, 2023)

Previous studies in Kenya reveal that awareness of sustainability concepts has always been high dating far back. A study conducted in the year 2015 found that 93% of the construction industry stakeholders involved in the development of commercial buildings in Nairobi were familiar with sustainable building concepts . However, the research further revealed that only a paltry 7% of these sustainability concepts were implemented in the actual construction. A recent study revealed that at least 80% of construction professionals in Kenya demonstrated knowledge of sustainable construction principles related to energy efficiency, water efficiency, sustainable site practices, sustainable materials, and indoor environmental quality . Further, the study showed awareness was highest on water efficiency and sustainable site practices at 93% while the use of sustainable construction materials scored 80%. Another study conducted on property developers of residential buildings in Kenya revealed that the level of awareness ranged between 56% (sustainable materials) to 83% (indoor environmental quality and an overall level of awareness of 71.6% . It is clear from these various findings that awareness of green building concepts is not a barrier in the process of implementing sustainable construction.

The high level of awareness is not unique to Kenya. In Nigeria, a study conducted on students undertaking construction-related courses revealed a significant proportion of the sample population was aware of sustainable construction concepts, though only a few had a deep understanding of the underlying principles . The study determined that there was an urgent need to incorporate sustainability courses into the curriculum of construction industry students. Further, industry stakeholders should prioritize the integration of such concepts into their designs and construction practices, since students tend to emulate their work. Results of another study suggested that a significant proportion of construction industry professionals in Nigeria possess knowledge of green building rating systems . Elsewhere in Zambia, a survey of construction industry professionals established that the enviro-centric aspect of sustainability was well understood . Such awareness serves as a crucial driver towards pushing the sustainable construction agenda across the country and continent at large.

Adoption of Sustainable Construction Practices

The second objective of the study was to establish the extent of the adoption of sustainable construction practices in construction projects in Kenya. This was broken down into five elements namely; water efficiency, energy efficiency, sustainable sites, sustainable materials, and indoor environmental quality.

Water Efficiency

Seven water efficiency measures were considered in this study. As presented in Table 2, the most practiced measures were; water-efficient plumbing fixtures (mean=4.29, 85.8%), installation of water supply sub-meters (mean=4.13, 82.6%), and rainwater harvesting (mean=3.67, 73.4%). The least practiced measures were; grey and black water recycling (mean=2.53, 50.6%), the use of efficient irrigation technologies (mean=2.92, 58.4%), and the use of native plants and xeriscaping (mean=3.02, 60.4%).

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Table 2: The extent of Adoption of Water Efficiency Measures

Water Efficiency Measures	N	Mean	Std. Dev.	Rank
Rainwater Harvesting	180	3.67	1.227	3
Grey and black water recycling	180	2.53	1.283	7
Water-efficient plumbing fixtures	180	4.29	0.857	1
Install water supply sub-meters	180	4.13	1.073	2
Use of non-potable water for flushing and external use	180	3.36	1.281	4
Use of native plants and xeriscaping	180	3.02	1.277	5
Use of efficient irrigation technologies	180	2.92	1.301	6

Source (Fieldwork, 2023)

The results found in this study are not very different from those established by other researchers. For example, a study on green building practices in Kakamega County in Kenya also revealed that the two most practiced water efficiency measures were rainwater harvesting and the use of efficient plumbing fixtures respectively . The study also reported wastewater recycling as the least adopted method just as seen in Table 2. Elsewhere in Langata, Nairobi the extent of wastewater recycling was reported to have a mean of 2.10 (42%) in residential buildings . The reason for the low adoption of wastewater recycling practices could be due to social and cultural perceptions that recycled water is considered not to be clean enough for home use .

The use of water sub-meters which was ranked second (mean=4.36, 87.2%) was also found to be very common in previous studies. Water metering is a tool employed to track water consumption, identify leaks, monitor demand, and strategize its supply to users. In Nairobi, Chebet *et al* (2024) reported the extent of use of water sub-meters at a mean of 3.61 (72.2%). Another study conducted in Nakuru and Kisumu counties revealed that water sub-meters are used to a great extent since residents are keen to monitor their water consumption . Though the high extent of adoption of water sub-meters could be attributed to landlords of rental housing intending to pass the burden of water costs to individual tenants in Kenya, nevertheless it contributes to a great extent to water conservation.

Energy Efficiency

Energy efficiency was evaluated based on 9-point criteria. As shown in Table 3, the most practiced measures were; the use of daylighting (mean=4.46, 89.2%), the use of energy-efficient fittings and appliances (mean=4.17, 83.4%), and the use of efficient building mechanical systems and appliances (mean=3.93, 78.6%). The least practiced measures were; the use of green power and carbon offsetting (mean=2.46, 49.2%), wall and roof insulation and high-performance glazing (mean=3.46, 69.2%), and building energy management system with embedded demand response technologies (mean=3.32, 66.4%).

Table 3: The extent of Adoption of Energy Efficiency Measures

Energy Efficiency Measures	N	Mean	Std. Dev.	Rank
Use of renewable energy sources	180	3.81	1.144	4
Use of daylighting	180	4.46	0.787	1
Use of artificial lighting control	180	3.80	1.126	5
Use efficient building mechanical systems and appliances	180	3.93	1.014	3
Wall and roof insulation and high-performance glazing	180	3.46	1.150	7
Use of green power and carbon offsetting	180	2.46	1.225	9
Practice preventive maintenance	180	3.75	1.152	6
Building Energy Management system with embedded demand response technologies	180	3.32	1.331	8
Use energy-efficient fittings and appliances	180	4.17	0.925	2

Source (Fieldwork, 2023)

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Previous studies in Kenya show that energy-efficient lighting systems are some of the most common methods of sustainable construction . Further, the most common energy efficiency strategies adopted in Kenya include the utilization of energy-efficient light bulbs, powering down appliances when not in use, and harnessing solar energy . As shown in Table 3, the extent of use of renewable energy sources and adoption of energy management systems were rated at a mean of 3.81 (76.2%) and 3.32 (66.4%) respectively compared to 3.55 (71%) and 3.46 (69.2%) as reported by Chebet, *et al* (2024). Further, the study concluded that most residential houses in Langata, Nairobi have installed solar heating systems as a way of lowering the cost of energy in their homes. Previous studies have demonstrated that energy management systems provide social, economic, and environmental benefits to users . The study recommended increased use of light controls and smart meters. Contrastingly, Chebet, *et al* (2024) reported a moderate extent of adoption of daylighting with a mean score of 3.39 (67.8%) compared to the 4.46 (89.2%) seen in Table 3. Other than the environmental and economic benefits, the use of natural lighting has been reported to have health benefits since it is believed to reduce stress and discomfort and is also good for vision .

The use of energy-efficient fittings and appliances ranked second in Table 3 with a mean of 4.17 (83.4%) and has also been reported in previous studies to be very common due to huge energy-saving potential in measures like LED lighting which offers better brightness, contrast, and are almost 10 times as effective compared to 8 traditional bulbs .

Sustainable Sites

The extent of adoption of sustainable sites was evaluated based on an 11-point criterion. As shown in Table 4, the most practiced measures were; site landscaping (mean=4.42, 88.4%), adherence to local zoning requirements (mean=4.39, 87.8%), and efficient stormwater management (mean=4.33, 86.6%). The least practiced measures were; reducing the heat island effect by use of green roofs (mean=3.03, 60.6%), promoting the use of alternative transportation (mean=3.18, 63.6%), and reusing/restoring previously developed land (mean=3.50, 70.0%).

Table 4: The Extent of Adoption of Sustainable Sites

Sustainable Sites Measures	N	Mean	Std. Dev.	Rank
Adherence to local zoning requirements	180	4.39	0.983	2
Preserving existing ecosystems.	180	3.98	1.038	6
Site landscaping	180	4.42	0.832	1
Efficient storm water management	180	4.33	0.934	3
Reusing/restoring previously developed land	180	3.50	1.244	8
Promote the use of alternative transportation	180	3.18	1.288	10
Stewardship of nature and site surroundings	180	3.73	1.039	7
Reducing heat island effect by use of green roofs	180	3.03	1.172	11
Reducing light trespass and pollution	180	3.33	1.205	9
Conducting site environmental assessments	180	4.14	1.025	4
Providing external spaces	180	4.14	1.031	4

Source (Fieldwork, 2023)

Two of the most practiced sustainable site practices reported in Table 4, i.e., site landscaping and efficient stormwater management, were termed as critical features of sustainable construction which ensure soil conservation and maintenance of aesthetics around buildings by Kanda, et al., (2023). Though the use of green roofs was ranked as the last factor with a mean of 2.96 (59.2%), Khaemba and Mutsune (2014) reported the use of roof materials with better heat reflection as more common with a mean of 3.85 (77.0%).

Sustainable Materials

The extent of adoption of sustainable materials was evaluated based on a 12-point criterion. As

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shown in Table 5, the most practiced measures were; the use of locally sourced and manufactured materials (mean=4.44, 88.8%), the use of materials from manufacturers that meet environmental product declarations (mean=4.19, 83.8%), and developing a solid waste management policy during construction and maintenance (mean=3.99, 79.8%). The least practiced measures were; the use of biobased and other rapidly renewable materials (mean=3.32, 66.4%), the installation of a material usage tracking system (mean=3.37, 67.4%), and the use of recycled and recyclable materials (mean=3.69, 73.8%).

Table 5: Extent of Adoption of Sustainable Materials

Adoption of Sustainable Materials	N	Mean	Std. Dev.	Rank
Use of locally sourced and manufactured materials	180	4.44	0.771	1
Use of recycled and recyclable materials	180	3.69	1.079	10
Recycling waste during construction	180	3.86	1.089	7
Reusing existing buildings and materials	180	3.77	1.073	9
Design optimized and flexible spaces	180	3.94	1.079	5
Use materials from manufacturers that meet environmental product declarations	180	4.01	1.070	2
Use of low emitting and less toxic materials	180	3.97	1.030	4
Use responsibly extracted materials	180	3.85	1.065	8
Developing a solid waste management policy during construction and maintenance	180	3.99	1.075	3
Use of biobased and other rapidly renewable materials	180	3.32	1.189	12
Install material usage tracking system	180	3.37	1.430	11
Conducting regular material audits	180	3.92	1.250	6

Source (Fieldwork, 2023)

The use of locally sourced and manufactured materials was also ranked first in the study by Khaemba and Mutsune (2014) with a mean of 4.13 (82.6%). In the same research, use of recycled and recyclable materials was reported to have a mean of 3.85 (77.0%), almost equal to the mean presented in Table 5 (3.86, 77.2%) though the ranking was not the same in both studies. Reusing of existing buildings was reportedly not highly popular both in this study and in previous research .

Indoor Environmental Quality

The level of adoption of Indoor Environmental Quality was evaluated based on a 6-point criterion. As shown in Table 6, the most practiced measures were; enhanced natural ventilation (mean=4.48, 89.6%), provision of quality views for occupants (mean=4.44, 88.8%), and the use of low-emitting finishes (mean=4.16, 83.2%). The least practiced measures were the provision of smoking areas (mean=3.52, 70.4%), and the use of thermal control units (mean=3.68, 73.6%).

Table 6: Extent of Adoption of Indoor Environmental Quality Measures

Indoor Environmental Quality Measures	N	Mean	Std. Dev.	Rank
Enhancing natural ventilation	180	4.48	0.855	1
Use of low-emitting finishes	180	4.16	0.940	3
Providing quality views for occupants	180	4.44	0.785	2
Prevention of noise within and outside the building	180	4.08	0.956	4
Provision of smoking areas	180	3.52	1.326	6
Use of thermal control units	180	3.68	1.184	5

Source (Fieldwork, 2023)

Indoor Environmental Quality (IEQ) plays a crucial role in ensuring a comfortable indoor environment and preventing sick building syndrome. The ambient environment exerts both physical and emotional influence on building users therefore making it a crucial element in the design and development of buildings . The use of passive systems in the indoor space seems to be

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very popular among stakeholders in the construction industry of Kenya. This could be explained by the ranking of enhanced natural ventilation as first with a mean of 4.48 (89.6%). A study by Wakhungu (2021) also ranked the use of daylight strategies first (mean=4.68, 93.6%). Passive systems are popular because they lower energy consumption and therefore reduce energy bills. In Wakhungu (2021), the prohibition of smoking inside buildings was reported to have an almost similar mean (3.71) as that presented in Table 6.

Overall Extent of Adoption of Sustainable Construction Practices

Sustainability is a crucial goal in global development. Countries, particularly in the West, have established mechanisms to guarantee the achievement of sustainable development, especially in areas of design and building as opposed to developing countries, such as those in Sub-Saharan Africa, where the progress is relatively sluggish .

Table 7: Extent of Adoption of Sustainable Construction Practices

Adoption of Sustainable Construction Practices	N	Mean	%	Rank
Water efficiency	180	3.41	68.2%	5
Energy efficiency	180	3.68	73.6%	4
Sustainable sites	180	3.83	76.6%	3
Sustainable materials	180	3.84	76.8%	2
Indoor environmental quality	180	4.06	81.2%	1

Source (Fieldwork, 2023)

As demonstrated in Table 7, the study found that indoor environmental quality, sustainable materials, sustainable sites, energy efficiency, and water efficiency ranked from first to fifth respectively. The findings both support and contrast those from the past. For example, a study conducted in Nairobi, Kenya established the ranking from first to fifth as follows; energy efficiency measures, water efficiency, indoor environmental quality, sustainable materials, and sustainable sites . However, the ranking of water efficiency as the least adopted sustainable construction practice was also reported by another study in Lamu, Kenya . Interestingly, the same study reported energy efficiency as the most adopted green building practice while another study reported water efficiency as the most commonly adopted and energy efficiency as the least adopted . This is a clear indication that either the time factor has played a role in the dynamics of sustainable construction in Kenya or there is a need for further studies on the possible reasons for the contrasting results. The case for further studies is supported by another contrast reported in the overall mean for this study at 3.76 (75%) as opposed to 2.90 (58%) reported in a previous study which was conducted in Langata, Nairobi . Wakhungu (2021) on the other hand supports the findings in Table 7 by giving an overall mean of 3.78 (75.6%). Further, in an article published in the online *Nation* platform, the number of green buildings in Kenya increased twofold between 2021 and 2022 with commercial buildings leading the way .

Extent of Awareness Versus Adoption of Sustainable Construction Practices

In the case of water efficiency, energy efficiency, and sustainable sites, the extent of adoption of sustainable construction practices was lower than that of awareness. This has been demonstrated in Table 8. However, the level of adoption was higher than that of awareness in the case of sustainable materials and indoor environmental quality. As expected, the overall extent of adoption was slightly lower than that of awareness. Users cannot be expected to adopt green building practices if they are not aware of the existence of such practices and fully understand the benefits of the same.

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Table 8: Extent of Awareness Versus Adoption of SCPs

	Level of Awareness		Level of Adoption	
Sustainable construction practice	**Mean**	**Rank**	**Mean**	**Rank**
Water Efficiency in buildings	3.92	4	3.41	5
Energy Efficiency in buildings	4.06	3	3.68	4
Use of Sustainable Materials	3.66	5	3.83	2
Sustainable Site Practices	4.08	1	3.84	3
Indoor Environmental Quality	4.03	2	4.06	1
Overall Mean	**3.95 (79%)**		**3.76 (72.3%)**	

Source (Fieldwork, 2023)

The research hypothesis was tested using Pearson's Correlation analysis and the results have been presented in Table 9. Just as noted in the descriptive analysis presented in Table 8, and as expected, there was a statistically significant relationship between the extent of awareness and that of adopting sustainable construction practices. However, the strength of the relationship was found to be moderately weak at 0.569 (p=0.000). These results consequently mean that there is a need for increased awareness of green building practices as this will automatically lead to increased adoption of these practices. Such awareness could be enhanced by including sustainability in the curricula of construction-related academic programmes. Dissemination of available information on sustainable construction could also be achieved through social media, seminars, workshops, radio, and television stations.

Table 9: Correlation between Extent of Awareness and Adoption of SCPs

		Awareness	**Adoption**
Awareness	Pearson Correlation	1	.569**
	Sig. (2-tailed)		.000
	N	180	180
Adoption	Pearson Correlation	.569**	1
	Sig. (2-tailed)	.000	
	N	180	180

**. Correlation is significant at the 0.01 level (2-tailed).

Source (Fieldwork, 2023)

CONCLUSIONS AND RECOMMENDATIONS

Contrary to some previous research, the study makes the following conclusions; (i) construction industry stakeholders in Kenya are adequately aware of sustainable construction practices, (ii) the extent of adoption of sustainable construction practices in Kenya is moderately high. However, this is still inadequate as the goal is to ensure net zero-carbon emissions in construction projects. Therefore, the study makes the following recommendations;

- The government needs to formulate an elaborate legal and regulatory framework for sustainable construction. Such a framework should provide clear implementation guidelines including the institutional framework, financial incentives, and penalties associated with sustainability in the construction sector.
- Since developers hold high potential in the implementation of sustainable construction, the government and other development agencies should create more awareness amongst developers not only on the long-term financial benefits of green building, but also the health, social, and environmental benefits.
- Sustainable construction principles should be incorporated into the curricula of all construction-related programmes in tertiary institutions in Kenya. However, the basic concepts of sustainable construction should be introduced at lower levels of education.

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REFERENCES

Hakkinen, T., & Belloni, K. (2011). Barriers and drivers for sustainable building. *Building Research & Information, 39*(3), 239-255. doi: 10.1080/09613218.2011.561948

Ahn, Y. H., Pearce, A. R., Wang, Y., & Wang, G. (2013). Drivers and barriers of sustainable design and construction: The perception of green building experience. *International Journal of Sustainable Building and Urban Development, 4*(1), 35-45. doi: 10.1080/2093761X.2012.759887

Albert, K. (2018). *Voice Controlled Lighting System For The Elderly And Persons With Special Needs.* Doctoral dissertation, The Technical University of Kenya.

AlSanad, S. (2015). Awareness, Drivers, Actions, and Barriers of Sustainable Construction in Kuwait. *International Conference on Sustainable Design, Engineering and Construction. 118*, pp. 969-983. Safat: Kuwait Insitute for Scientific Research.

Ametepey, O., Aigbavboa, C., & Ansah, K. (2015). Barriers to successful implementation of sustainable construction inthe Ghanaian construction industry. *6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and theAffiliated Conferences* (pp. 1682 – 1689). Las Vegas, Nevada, USA: Elsevier Procedia.

Berardi, U. (2012). Sustainability Assessment in the Construction Sector: Rating Systems and Rated Buildings. *Sustainable Development, 20*, 411-424. doi:10.1002/sd.532

Brooks, A., & Rich, H. (2016). Sustainable construction and socio-technical transitions in London's mega-projects. *The Geograhical Journal, 182*(4), 395-405. doi:10.1111/geoj.12167

Chebet, M., Gweyi, J., & Kitur, E. (2024). Adoption of Green Building Practices in Langata, Nairobi City County, Kenya. *International Journal of Innovative Science and Research Technology, 9*(2), 182-192.

Darko, A., & Chan, A. P. (2016). Review of Barriers to Green Building Adoption. *Sustainable Development,* 1-13. doi:10.1002/sd.1651

DuPlessis, C. (2005). Action for sustainability: Preparing an African plan for sustainable building and construction. *Building Research & Information, 33*(5), 405-415. doi:10.1080/09613210500218974

Ezilondo, M., & Lofthouse, V. (2010). Towards A sustainable Use of Water at Home: Understanding How Much,Where and Why? *Journal of Sustainable Development, 3*(1), 3-10.

Fadhil, A. (2015). *Adoption of green practices in the hospitality and tourism industry in Lamu County, Kenya.* MA Thesis, University of Nairobi.

Ganiyu, B. O., Fapohunda, R. A., & Haldenwang, R. (2015). Construction Approaches to Enhance Sustainability in Affordable Housing in Developing Countries. *World Congress on Sustainable Technologies* (pp. 101-107). Durban: IEEE.

Ghazali, Z., & Zahid, M. (2015). Environmental Sustainability: Carbon Emission Reduction Strategies and Reporting among Malaysian Construction Companies. *International Symposium on Technology Management and Emerging Technologies (ISTMET)* (pp. 417-421). Lengkawi, Kedah, Malaysia: IEEE.

Hanjahanja, R., Omuto, C., & Biamah, E. (2018). Comparing Pre-Paid Communal Water Metering and Delegated Management in Urban Poor Setting: Case Studies in Nakuru and Kisumu in Kenya. *Current Urban Studies*, *6*(4), 483–498.

Heilman, V. M. (2016). *Factors Hindering the Adoption of Sustainable Design and Construction Practices: The Case of Office Building Development in Dar es Salaam,*

Article DOI: https://doi.org/10.37284/eaje.7.1.2131

Tanzania. University of Dar es Salaam, Dar es Salaam.

Ihuah, W. P., Kakulu, I. I., & Eaton, D. (2014). A review of Critical Project Management Success Factors (CPMSF) for sustainable social housing in Nigeria. *International Journal of Sustainable Built Environment, 3*(1), 62-71.

Kanda, E. K., Lusweti, E., Ngugi, F. N., Irungu, J. M., Omondi, B. O., & Waweru, S. G. (2023). Adoption of Green Building Practices in Kenya: A Case of Kakamega Municipality. In D. S.-K. Ting, & J. A. Stagner, *Pragmatic Engineering and Lifestyle* (pp. 153-169). Ontario: Emerald Publishing Limited. doi:10.1108/978-1-80262-997-220231008

Khaemba, P. (2013). *Adoption of green building practices and rating system in Kenya: Potentials and barriers.* Unpublished PhD Thesis, North Carolina Agricultural and Technical State University.

Khaemba, P., & Mutsune, T. (2014). Potential for green building adoption: Evidence from Kenya. *Global Journal of Business Research, 8*(3), 69–76.

Li-qun, L., Chun-xia, L., & Yun-guang, G. (2014). Green and sustainable City will become the development objective of China's Low Carbon City in future. *Journal of Environmental Health Science & Engineering, 12*(34), 1-10. Retrieved from http://www.ijehse.com/content/12/1/34

Mulei, D. N. (2020). *Evaluation of energy efficiency, indoor air quality and sustainability testing of green buildings in Nairobi, Kenya.* MSc Thesis, Jomo Kenyatta University of Agriculture and Technology.

Ndambuki, S. (2023, August 17). Green Buildings are doubling in Kenya, why is the residential sector lagging behind? Nairobi: Nation. Retrieved May 22, 2024, from https://nation.africa/kenya/business/green-buildings-are-doubling-in-kenya-why-is-the-residential-sector-lagging-behind--4337860

Nduka, D. O., & Sotunbo, S. A. (2014). Stakeholders Perception on the Awareness of Green Building Rating Systems and Accruable Benefits in Construction Projects in Nigeria. *Journal of Sustainable Development in Africa, 16*(7), 118-130.

Ofori, A., Aigbavboa, C., & Ansah, K. (2015). Barriers to successful implementation of sustainable construction in the Ghanaian construction industry. *6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015.* Kumasi.

Serpell, A., Kort, J., & Vera, S. (2013, June 17). Awareness, actions, drivers and barriers of sustainable construction in Chile. *Technological and Economic Development of Economy, 19*(2), 272-288. doi: 10.3846/20294913.2013.798597

Soori, P. K., & Vishwas, M. (2013). Lighting control strategy for energy efficient office lighting system design. *Energy and Buildings, 66*(1), 329–337.

Sourani, A. I., & Sohail, M. (2005). Realising Social Objectives of Sustainable Construction through Procurement Strategies. *Proceedings of the CIB W92/T23/W107 International Symposium on Procurement Systems* , (pp. 637-644). Las Vegas: Arizona State University.

Sundanyi, S., Tramontin, V., & Loggia, C. (2015). An Investigation into the Costs and Benefits of Green Building in South Africa. *World Congress on Sustainable technologies* (pp. 78-82). Durban: University of KwaZulu Natal.

Wakhungu, J. (2021). *Adoption Of Green Building Concepts In Residential Developments In Nairobi City County (A Perspective Of House Developers).* Unpublished Masters Thesis. University of Nairobi.

Were, S. (2015). *Investigation into the adoption of green building concepts in commercial*

Article DOI: https://doi.org/10.37284/eaje.7.1.2131

buildings: A case of Nairobi County. Jomo Kenyatta University of Agriculture and Technology, Unpublished Thesis, Department of Construction Management.

Wilson, I., & Rezgui, Y. (2013). Barriers to construction industry stakeholders' engagement with sustainability: toward a shared knowledge experience. *Technological and Economic Development of Economy, 19*(2), 289- 309. doi:10.3846/20294913.2013 .799105

Zaki, B. M., Ibrahim, A., & Adamu, A. (2016). A Study on the Level of Awareness of Sustainability Concepts in Construction amongst Students: The Nuhu Bamalli Polytechnic Experience. *Civil and Environmental Research, 8*(5), 149-157.

Zhang, Y., Wang, W., Wang, Z., Gao, M., Zhu, L., & Song, J. (2021). Greenbuilding design based on solar energy utilization. *Energy Reports, 7*, 1297–1307.

Zulu, S., Zulu, E., & Chabala, M. (2022). Sustainability Awareness and Practices in the Zambian Construction Industry. *Acta Structilia*, *29*(1), 112- 140. doi: http://dx.doi. org/10.18820/24150487/as29i1.5