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Key barriers to green building implementation in South Africa

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Declaration

All papers in this publication have been through a review process involving a review of abstracts, peer review of full papers by at least two referees, reporting of comments to authors, revision of papers by authors and re-evaluation of the revised papers to ensure quality of content.

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KEY BARRIERS TO GREEN BUILDING IMPLEMENTATION IN SOUTH AFRICA

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Due to climate change, South Africa is faced with economic and health challenges. Adopting green building technologies reduces the amount of energy usage, however the implementation of green building in South Africa has been slow.This research aimed to identify the barriers on the implementation of green building and the methods that can be adopted to enhance the growth of green building in South Africa.A qualitative research method was be adopted. The open-ended interviews were conducted with built environment professionals.The main barriers of green building implementation are: initial high cost, lack of awareness, lack of incentives, and resistance to change.Recommendations to enhance the growth of green building practices in South Africa include: updating building codes, expanding training programs, fostering collaboration between the public and private sectors, offering financial incentives, promoting the re-purposing of existing structures, and using performance-based contracts.The paper has highlighted the key barriers of green building implementation in South Africa and developed a database of the relevant studies which can further guide future researchers, stakeholders and policymakers in this area.

Keywords: green building, qualitative research, sustainability, South Africa

INTRODUCTION

Carbon dioxide emissions is the main contributor to climate change (Ritchie and Roser, 2020). The construction, operations and demolitions of buildings use energy, generate waste, and emit harmful atmospheric emissions (Agbajor et al, 2022).The risks of climate change have economic, environmental, social and health consequences (Rising et al.,2022; Applebaumet al.,2016; Owoha et al., 2022).

South Africa is facing major economic and health challenges caused by the impact of climate change that are stemming from poor implementation of sustainable development (Wright et al., 2021).Water scarcity has affected the food production in the country as the agriculture industry utilises large amounts of water to grow crops (World Bank Group, 2021). Due to the energy crisis, electricity load shedding had to be implemented. Therefore, alternative measures are desperately needed to preserve the natural resources for the future generation and reduce the building energy consumption (Opawole et al.,2020).

Green Building initiatives are solutions to reduce carbon emissions(Franco, 2021).The implementation of green building standards, certifications and rating systems were introduced with the aim to lower the impacts of infrastructure in the environment through sustainable

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design (Masia et al, 2020).However, Green Building through sustainable development is lagging behind in developing countries such as South Africa, resulting in the slow depletion of natural resources and an increase in climate change (Miranda et al.,2021). Moreover, Green Building certification reduces the amount of energy usage, however the implementation of green building in South Africa has been slow.

Load shedding, water scarcity and the increase in temperature validate that South Africa is slowly failing to meet the Green Building objectives which compromises the future generation. This matter is associated with low certification of green building, and therefore it results in new developments that are high in energy consumption and have a negative impact in the communities (Mushi et al.,2022).

This research main aim was to investigate the implementation of green building and the methods that can be adopted to enhance the growth of green building in South Africa.

The following were the objectives of the study:
Determine the benefits of implementing green building practices.

Determine the impact of poor implementation of green building practices.

Identify the key challenges faced by green building certification.

LITERATURE REVIEW

Sustainable development and green building

Green buildings are sustainable and take durability, cost, utility, and comfort into consideration (Yee et al., 2020).Green Building is the process of designing and constructing a building or structure utilizing sustainable and environmentally friendly practices (Yee et al., 2020). Lawluvy et al (2022) define Green Buildings as buildings that have a positive impact on the environment and the climate through their design, construction, or operation. Green Building practices have been introduced to limit the negative impact that the construction industry has on the environment (Cao et al., 2022).Green Buildings have a wide range of environmental, economic, and social advantages (Lawluvy et al., 2022). These advantages include a 25% boost in productivity, a 30% drop in energy use, a 38% drop in CO2 emissions, a 29% boost in thermal comfort satisfaction, and a life-cycle cost savings of more than 10 times the additional cost of building green (Lawluvy et al., 2022).

Sustainable development focuses on the quality of life for all the earth's occupants as most of the natural resources such as water, coal and other important minerals cannot be renewed once they have been depleted (Khoza and Rabie, 2021), therefore sustainable development encourages that natural resources to be utilized in such a way that future generations can still benefit from the same resources.

Tools and techniques used to certify a building

The Green Building Council of South Africa (GBCSA) was founded in 2007, a non-profit organization that oversees and promotes green building and sustainability through certification procedures, and this council only functions in South Africa (GBCSA, 2019). South Africa is increasingly recognizing the need to reduce the environmental impact of the built environment (Mushi et al.,2022). Green Building South Africa aims to promote sustainable construction and operation of buildings by implementing key features such as energy efficiency, water conservation, sustainable materials, waste reduction, and indoor air quality (Aboginije et al.,2020). These key features include energy-efficient technologies, water-saving measures, sustainable materials, responsible waste management practices, and proper ventilation (Aboginije et al.,2020).The Green Star rating system developed by the Green Building Council

of South Africa (GBCSA, 2019), evaluates the environmental performance of buildings, and encourages sustainable practices. The government should play a pivotal role in promoting green building through policies, regulations, and incentives (Okwandu et al., 2024).

Energy conservation, low building operating costs, and healthy interior air circulation are some of the environmental measures that are enforced by GBCSA (GBCSA, 2019). The GBCSA certifies buildings using a variety of approaches and technologies, including green star, EWP, Net Zero, and the EDGE rating tool (GBCSA, 2019). The Green Star SA rating tools are designed to evaluate various aspects of a building's or development's environmental performance and promote sustainable construction practices across the country (Wen, 2020). These tools include Green Star SA - Building rating tools, which assess the environmental performance of individual buildings in various sectors, such as office buildings, retail centers, and multi-unit residential buildings (Ade and Rehm, 2020). They evaluate criteria such as energy efficiency, water usage, indoor environmental quality, materials, and innovation (Ade and Rehm, 2020).

Benefits of green building

Green buildings are beneficial for sustainable development initiatives, contribute positively to reducing climate change, greenhouse gas emissions, and global warming. Previous research has shown the various advantages and benefits to green building projects (Oguntona et al.,2019; Simpeh and Smallwood ,2018;Windapo and Goulding, 2015; Ebekozien et al., 2022; and Khoza and Rabie (2021).

Environmental benefits

According to Simpeh and Smallwood (2018), the environmental benefits of green building are,the protection of ecosystems and biodiversity; restoration and conservation of natural resources; reduced water use; and improved water and air quality. Similarly, Khoza and Rabie (2021) has also revealed that green buildings improve water and air quality, protect ecosystems, restore, and preserve renewable and natural resources, and reduce the flow of waste into the air and land. Green Buildings reduce heat gain, especially when buildings are designed and oriented to optimize the use of daylight (Khoza and Rabie, 2021).

Financial and Economic benefits

Green buildings provide several direct and indirect economic benefits (Simpeh and Smallwood, 2018). The direct benefits include a better payback period for green buildings due to low energy and water use, lower healthcare costs, and direct economic benefits in terms of a quick return on investment as well as increased revenue (Simpeh and Smallwood, 2018). The net- zero buildings enhance the productivity of occupants, reduced operating costs, the shaping and value of buildings increases because owners and developers can make more money by renting out their buildings as compared to non-green buildings (Khoza and Rabie, 2021). In addition, Green Buildings bring higher rental rates, which range from 5 to 10 percent, and a higher market value of 10 percent, as revealed by Oguntona et al., (2019).

Oguntona et al., (2019) show that the Leadership in Energy and Environmental Buildings green rating system reduces energy consumption by 30% while productivity is raised by 25%. Another benefit is the branding and prestige because green buildings are a different kind of product that is technologically, environmentally, and socially responsible (Simpeh and Smallwood, 2018). The economic advantages of expansion of markets for green services and products, and optimized economic performance over a building's lifetime (Khoza and Rabie, 2021).

Social benefits

Social benefits associated with Green Buildings include improved health, comfort for occupants and a pleasant environment to live in (Smallwood and Simpeh, 2018).The social and community aspects of green buildings offer additional opportunities in terms of job creation for local people. Given that Green Buildings are a new form of construction, younger generations will conduct research and explore the field, thus providing many employment opportunities (Smallwood and Simpeh, 2018).

Industry and market benefits

Market-side benefits include reduced advertising costs, corporate recognition, meeting growing tenant demand, lower vacancy rates, higher occupancy rates, and value creation within compatible markets (Liu et al.,2022).The construction sector will benefit from Green Buildings as technology will be incorporated into the process; project outcomes will improve; professionals will become more qualified, educated, and integrated; opportunities will be opened for other nations, and other industries will gain from new opportunities apart from the construction sector (Khoza and Rabie , 2021).

The poor implementation green buildings

Environmental issues, climate change, an energy crisis, and a water deficit are putting South Africa under pressure to adopt green buildings (Simpeh & Smallwood, 2018). Despite the growing awareness of green buildings, there is still a slow adoption and development of it in the construction industry (Simpeh & Smallwood, 2018).There has been a call for a more sustainable approach to construction as the current construction sector practices pose a serious threat to the environment and depletes the planet's finite resources (Aghimien et al.,2018).

The importance of input and output activities in the construction sector is widely acknowledged (Oguntona et al.,2019). The construction industry contributes to the infrastructure development such as hospitals, schools, and other required facilities, which are employed to create commodities and services for the people, it helps to shape the Socio-Economic of the citizens (Oguntona et al.,2019). However, both the people occupying the building and the building itself are affected by the location of the building, the materials used, and the way it was constructed (Oguntona et al., 2019).

Environmental impact

Green buildings are constructed to be both environmentally and energy friendly (Yee, et al., 2020). A significant portion of the global pollution that is produced is due to the construction industry. As one of the largest consumers of power, buildings contribute to both global warming and the depletion of our natural resources (Walt et al.,2018). Construction practices need to be changed to lessen the consequences that the built environment has.

Health and well-being

By utilizing materials that enhance indoor air quality and natural illumination, green buildings put a priority on occupant health and well-being (Owoha et al., 2021). Green buildings are more efficient in terms of energy use, greenhouse gas emissions, waste production, occupant productivity, and health (Simpeh and Smallwood, 2018).

Waste management

Water is one of the most important natural resources, it is necessary for life, food, and health, however, it is negatively impacted by climate change, global warming, population increase, and urbanization (Khoza and Rabie, 2021). By 2050, the world's population is predicted to increase from 7 billion to 9 billion, significantly polluting the air and water and placing pressure

on the ecosystem (Oguntona et al., 2019). The environment becomes overburdened as a result of the increased demand for water, electricity, and natural resources.

Energy usage

One of the benefits of using green features on your building is that it reduces consumption of energy and resources especially when it comes to the gas and electricity needed to heat and cool them (Simpeh and Smallwood (2018). Khoza and Rabie (2021) further states that buildings consume enormous amounts of electricity for air conditioning, heating, lighting and other purposes, which puts a serious constraint on the supply and generation of electricity in South Africa, which depend on coal for this purpose.

METHODOLOGY

The purpose of this study was to identify the key barriers preventing full implementation of green building practices in South Africa. The research took place in two phases. The first phase was a pilot study. A questionnaire was sent out to twenty professionals in the built environment. The pilot study was conducted to assist in ensuring the correct questions are included in the interviews. Twenty professionals were chosen as a sample size due to resource constraints, furthermore the aim of the study was not to study the entire population but rather get a snapshot of the key barriers of green building implementation in South Africa.

In the second phase, the study adopted a qualitative research method through semi structured interviews. A purposive sample of twenty professionals in the built environment and property owners (commercial) were invited for the interview, however only ten developers and owners agreed to participate in the interviews. The interviews took place online (MS Teams) and the interviews were recorded on consent of participants.

Data was collected from the professionals familiar with green building practices who also possess a high level of education and at least five years of professional experience in the built environment sector. The data was coded using themes and concept.

DATA ANALYSIS AND DISCUSSION

The implementation of green buildings in South Africa

The research participants had knowledge and understanding of the green building concept, they were able to provide us with a brief explanation of what green building is. The practicality of green buildings in South Africa is influenced by a combination of environmental, economic, regulatory, and social factors. When designed and implemented correctly, green buildings can contribute to environmental sustainability, energy efficiency, and cost savings while enhancing the well-being of occupants. South Africa is currently facing energy challenges with power shortages being a common issue. Thus, green buildings can assist in reducing energy consumption through features such as energy-efficient lighting, heating and cooling systems, solar panels, and the use of environmentally friendly building materials.

Water scarcity in South Africa is a crisis and green buildings can assist in alleviating this matter since they can incorporate water-saving technologies such as rainwater harvesting, greywater recycling, and low-flow fixtures to reduce water consumption. The participants have also stated that the location and infrastructure of a building can also influence its practicality. Access to public transportation, urban planning, and proximity to amenities can influence the success of green building projects. However, the success of green building projects depends on the availability of skilled professionals who can design, construct, and maintain green

buildings. Although South Africa may be lagging in terms of green building implementation, it has made significant progress in incorporating green building practices into its building codes and regulations, with initiatives like the Green Building Council South Africa's Green Star rating system promoting green building.

Concerns regarding the implementation of green buildings in South Africa

Table 1: Responses: Reasons for slow implementation of green buildings in South Africa

Concerns	Responses
Initial cost concerns	70%
Education and awareness	100%
Lack of incentives	100%
Resistance to change	100%

Initial cost concerns

The majority of the respondents (70%) indicated that the belief that green building practices are more expensive than traditional construction methods is one of the main obstacles hindering rapid growth of green buildings in South Africa. These types of buildings may be more expensive initially, but in the long run, they save money on energy and other operating costs. Most of the time, lack of knowledge about these advantages is what prevents investment in sustainable building. Furthermore, obtaining funding for green building projects, especially for smaller developers or those lacking a history in sustainable construction, can present difficulties. Financial institutions and banks might exercise caution when it comes to financing projects perceived as innovative or carrying higher perceived risk.

Education and awareness

The respondents mentioned that a lack of awareness and knowledge about green building practices and their benefits can hinder adoption. It is important that architects, engineers, contractors, and building owners are educated and trained to promote the adoption of green buildings and sustainable development.

Lack of incentives

The respondents pointed out that the presence of financial incentives, tax relief, or government support for green building projects can strongly encourage their adoption. In South Africa, the lack of strong incentives or well-defined policy structures dissuade developers and builders from giving priority to sustainability. They went on to elaborate that the presence of inconsistent or insufficient building codes and regulations that endorse sustainable construction is a major obstacle. What is required are explicit and supportive policies to establish guidelines and encourage the embrace of environmentally friendly practices.

Resistance to change

Another obstacle impeding the acceptance of green building practices is the reluctance of construction industry professionals, particularly builders and contractors who are well-versed in conventional construction techniques, to embrace new approaches. This resistance can decelerate the adoption of sustainable building practices. Clients are no different in this regard.

General recommendations

Most of the participants believe that the accelerated expansion of green buildings in South Africa will offer a more feasible solution to the various challenges the country is confronting, including the depletion of natural resources and the rise in climate change. The diverse climate of South Africa, characterized by fluctuating temperature ranges and irregular rainfall patterns, plays a significant role in shaping the planning and execution of eco-friendly building elements. For instance, many regions in the country can efficiently harness solar energy, but in drought-

prone areas, the emphasis is placed on the crucial importance of water-efficient design. To promote the adoption of green building in South Africa, it was suggested that the government improve and update building codes to include green building standards and requirements, develop and expand training programs for all the professionals in the construction industry to enhance their knowledge of green building practices. The participants also pointed out that to influence the positive growth of green building in South Africa, the industry should contemplate fostering collaboration between the public and private sectors to drive green building initiatives. Encourage the government and financial institutions to offer incentives like tax breaks, subsidies, or low-interest loans for green building projects. They further suggested that the construction industry encourages the repurposing and refurbishment of current structures, which lessens the demand for new construction and reduces waste. Another participant mentioned that to motivate the contractors and the designers to prioritize sustainable development, performance- based contracts that tie compensation to the achievement of sustainability goals should be used.

Demographic analysis and validity

The study's participants consisted of professionals within the construction industry, such as quantity surveyors, architects, engineers, project managers, and construction managers. The requirement was that they possessed a minimum of five years of professional experience and had been involved in diverse projects. This criterion was essential to examine their insights regarding the concept of green building and determine if their experiences in the South African construction industry aligns with the findings of the literature review.

Highest formal qualifications

It's crucial to emphasize that all participants possess appropriate tertiary education qualifications. These qualifications include national diplomas (10%) and bachelor's degrees (90%), with a majority holding BSc (Hons) degrees (70%), along with a significant number having master's degrees (20%) and doctoral degrees (10%). This indicates that the respondents had the necessary educational background to comprehend and respond effectively to the survey questions. Furthermore, a substantial portion of the sample comprises professionals with bachelor's degrees, followed by those with BSc (Hons) degrees and master's degrees.

Profession

The sample of respondents included construction professionals within the South African construction industry. This sample consisted of architects (20%), quantity surveyors (20%), green building consultants (10%), project managers (20%), consulting engineers (20%), and construction managers (10%). This demonstrates that the respondents encompass a wide range of professions within the construction industry and related fields. The quantity surveyors and a project manager are employed by companies recognized as level 2 B-BBEE contributors, the green building consultant comes from a company that certifies buildings, all other professionals (architects, engineers, construction manager and a project manager) are working for companies recognized as level 1 contributors.

Benefits of green building

The findings from the literature review and interviews indicated the importance of green buildings as a part of the global sustainable development discourse on natural resources, human beings, and the environment. According to respondent 4, green buildings are healthy structures that help mitigate the catastrophic effects of greenhouse gas emissions, climate change, and global warming. Responses from the interviews stated several reasons for the respondents to embark on the green project. The responses are as follows:

Table 2: Responses for benefits of green building

Benefit	Responses
Eco-Friendly	10%
Cost Saving	20%
Reduces usage of carbon, water, energy and waste	20%
Reduces GHG emission, climate change and global warming.	10%
Profitable	10%
Client Demand	30%

Impacts

The responses from the interviews and literature review illustrated how important is the adoption of green building and the impact of poor implementation of net zero practices. According to respondents 3, 6, and 7, the energy usage and carbon footprint will increase in the absence of green buildings. This issue exacerbates problems like air pollution, a lack of fresh water, and depletion of natural resources while also accelerating climate change and environmental deterioration. As stated above, one of the benefits of green building is to improve indoor air quality. Interviewee 1 corroborated this statement: Insufficient ventilation, air pollution, and lighting can lead to health problems for the occupants. Respondents 2, 9, and 5 further state that water is a necessity as we need it to survive and do the basic stuff. Water has been scarce in rivers and dams due to reduced rainfall that is caused by GHG emissions, climate change, and global warming. Hence respondent 4 believes green practices are important to preserve such precious resources for future generations. According to Smallwood and Simpeh (2018), one of the benefits of net zero building is to reduce energy usage. Respondent 8 and 10 further states that South Africa is currently facing an energy crisis also known as load shedding which result in a rise cost of fuel, inflation, unemployment, loss of productivity, and many more.

Tools, techniques, and procedures

There are certain qualities and requirements that a building has to possess for it to be deemed green. The responses from the interviews can attest to that. The organization that is responsible for certifying the buildings is GBCSA. 50% of the responses from the interview state that the features and elements of green building are the efficient use of water and energy, and waste management while 20% of the responses state that the features of green building are the use of sustainable materials, indoor air quality and water conservation. 30% of the respondents further state that energy-efficient technologies, water-saving measures, sustainable materials, responsible waste management practices, and proper ventilation are the key features of green buildings.

Challenges

The barriers of implementing green building include initial cost concerns, lack of education and awareness, lack of incentives, and resistance to change (Yee, et al., 2020). Windapo and Goulding (2015) identified some challenges being lack of awareness and the gap between green building practices and legislation requirements.

Respondents were asked to rate factors on a scale of 1 to 5, where 1 is not considered a factor and 5 is considered a factor and is a major factor. `

According to the response from the interviews, the major factor is the initial cost which is followed by the lack of education and awareness as the second highest factor. The third and fourth highest factors are seen as the lack of incentives and resistance to change.

CONCLUSION

The study's findings provide insights into the benefits of green building practices. Respondents in this research have highlighted various benefits, including eco-friendly, cost savings in the long run, reduced carbon, water, energy, and waste usage, mitigation of greenhouse gas emissions, climate change, and global warming, profitability, improved indoor air quality, enhanced occupant health and comfort, and overall environmental benefits. These responses demonstrate that the study successfully identified the benefits of implementing green building practices in South Africa.

This study also analysed its objective to identify the impact of poor implementation of green building practice. Respondents mentioned that without green buildings, energy usage and carbon footprint would increase, exacerbating problems like air pollution, water scarcity, and depletion of natural resources. This highlights the importance of green building practices in mitigating environmental and health impacts, thus addressing the objective of identifying the impact of poor implementation. This study has identified the challenges faced to certify green buildings. These challenges serve as barriers to the certification and widespread adoption of green building practices in South Africa.

REFERENCES

Aboginije, A., Aigbavboa, C., Thwala, W. and Samuel, S., (2020). Determining the impact of construction and demolition waste reduction practices on green building projects in Gauteng province, South Africa. Proceedings of international engineering & operations management, Dubai, UAE, pp.10-12.

Ade, R. and Rehm, M., (2020). The unwritten history of green building rating tools: A personal view from some of the 'founding fathers'. Building Research & Information, 48(1), pp.1-17.

Aghimien, D.O., Adegbembo, T.F., Aghimien, E.I. and Awodele, O.A., (2018). Challenges of sustainable construction: a study of educational buildings in Nigeria. International Journal of Built Environment and Sustainability, 5(1).

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

Applebaum, K.M., Graham, J., Gray, G.M., LaPuma, P., McCormick, S.A., Northcross, A. and Perry, M.J., (2016). An overview of occupational risks from climate change. Current environmental health reports, 3, pp.13-22.

Cao, Y., Xu, C., Kamaruzzaman, S.N. and Aziz, N.M., (2022). A systematic review of green building development in China: Advantages, challenges and future directions. Sustainability, 14(19), p.12293.

Climate Risk Profile:South Africa (2021):The World Bank Group

Ebekozien, A., Ikuabe, M., Awo-Osagie, A.I., Aigbavboa, C. and Ayo-Odifiri, S.O., (2022). Model for promoting green certification of buildings in developing nations: a case study of Nigeria. Property Management, 40(1), pp.118-13

Franco, M.A.J.Q., Pawar, P. and Wu, X., (2021). Green building policies in cities: A comparative assessment and analysis. Energy and buildings, 231, p.110561

Green Building Council South Africa, Integrated Annual Report, 2019

Khoza, S. and Rabie, B. (2021) "Investigating the Potential Use of Public Private Partnerships to Fund Green Building Initiatives," ResearchGate [Preprint]. Available at: https://www.researchgate.net/publication/359159989_Investigating_the_Potential_Use_of_Publi c_Private _Partnerships_to_Fund_Green_Building_Initiatives. Last accessed 27 June 2024

Lawluvy, Y.K., Ahiadu, A.A. and Ntim, O.K., (2022). Willingness To Pay For Green Buildings In Ghana: The Impact Of Benefit Sensitisation (No. 2022-032). African Real Estate Society (AfRES).

Liu, T.; Chen, L.; Yang, M.; Sandanayake, M.; Miao, P.; Shi, Y.; Yap, P.-S. Sustainability Considerations of Green Buildings: A Detailed Overview on Current Advancements and Future Considerations. Sustainability 2022, 14, 14393. https://doi.org/ 10.3390/su142114393 Last accessed 27 June 2024

Masia, T., Kajimo-Shakantu, K. and Opawole, A., (2020). A case study on the implementation of green building construction in Gauteng province, South Africa. Management of Environmental Quality: An International Journal.

Miranda, I.T.P., Moletta, J., Pedroso, B., Pilatti, L.A. and Picinin, C.T., (2021). A review on green technology practices at BRICS countries: Brazil, Russia, India, China, and South Africa. Sage Open, 11(2), p.21582440211013780.

Mushi, F.V., Nguluma, H. and Kihila, J., (2022). A critical review of African green building research. Building Research & Information, 50(6), pp.610-627.

Oguntona, O.A., Aigbavboa, C.O. and Mulongo, G.N., (2019). An assessment of lean construction practices in the construction industry. In Advances in Human Factors, Sustainable Urban Planning and Infrastructure: Proceedings of the AHFE 2018 International Conference on Human Factors, Sustainable Urban Planning and Infrastructure, July 21-25, 2018, Loews Sapphire Falls Resort at Universal Studios, Orlando, Florida, USA 9 (pp. 524-534). Springer International Publishing.

Opawole, A., Babatunde, S.O., Kajimo-Shakantu, K. and Ateji, O.A., (2020). Analysis of barriers to the application of life cycle costing in building projects in developing countries: A case of Nigeria. Smart and Sustainable Built Environment, 9(4), pp.503-521.

Owoha, F., Simpeh, E.K., Fapohunda, J.A., Ahadzie, D.K. and Mensah, H., (2022). Categorising green building features in developing countries: The case of South Africa. Journal of Engineering, Design and Technology, 20(6), pp.1627-1647.

Okwandu, A.C., Esho, A.O.O., Iluyomade, T.D. and Olatunde, T.M., (2024). The role of policy and regulation in promoting green buildings. World Journal of Advanced Research and Reviews, 22(1), pp.139-150.

Ritchie, H., Roser, M. and Rosado, P., (2020). CO and greenhouse gas emissions. *Our world in data*.

Rising, J., Tedesco, M., Piontek, F. and Stainforth, D.A., 2022. The missing risks of climate change. Nature, 610(7933), pp.643-651

Simpeh, E.K. and Smallwood, J.J., (2018). Analysis of the benefits of green building in South Africa. Journal of Construction Project Management and Innovation, 8(2), pp.1829-1851.

Wen, B., Musa, S.N., Onn, C.C., Ramesh, S., Liang, L., Wang, W. and Ma, K., (2020). The role and contribution of green buildings on sustainable development goals. Building and Environment, 185, p.107091.

Wieser, A.A., Scherz, M., Passer, A. and Kreiner, H., (2021). Challenges of a healthy built environment: Air pollution in construction industry. Sustainability, 13(18), p.10469.

Windapo, A.O. and Goulding, J.S., (2015). Understanding the gap between green building practice and legislation requirements in South Africa

Wright, C.Y., Kapwata, T., Du Preez, D.J., Wernecke, B., Garland, R.M., Nkosi, V., Landman, W.A., Dyson, L. and Norval, M., (2021). Major climate change-induced risks to human health in South Africa. Environmental Research, 196, p.110973.

Yee, H. C., Ismail, R. and Jing, K. T. (2020) "The Barriers of Implementing Green Building in Penang Construction Industry", Progress in Energy and Environment, 12, pp. 1–10. Available at: https://www.akademiabaru.com/submit/index.php/progee/article/view/1060 Last accessed: 21 March 2023



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