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# DRIVERS AND EFFECTS OF SUSTAINABLE CONSTRUCTION IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

RESEARCH ARTICLE[1]

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## ABSTRACT

Sustainable construction is hardly practised in Africa, despite the consistent campaign for its adoption. This study investigates the drivers and effects of sustainable construction in South Africa. The quantitative survey research design was adopted for the study and the respondents were the construction organisations in Johannesburg, South Africa. The study identified 17 significant drivers of sustainable construction, with construction cost as the dominant variable. The important environmental (8), economic (12), and social benefits (7) of sustainable construction were also determined. The challenges (24) of sustainable construction were also identified. The study recommended that measures for low construction cost should be put in place, and awareness campaigns should be enhanced. Economic benefits are still behind environmental benefits, and this could affect some prospective adopters. Lack of knowledge and weak economies were prevalent challenges that underscore the need for Western support for African nations to comfortably adopt sustainable construction.

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## ABSTRAK

Volhoubare konstruksie word min in Afrika beoefen ten spyte van die konsekwente veldtog vir die aanvaarding daarvan. Hierdie studie ondersoek die dryfvere en uitwerking van volhoubare konstruksie in Suid-Afrika. Die kwantitatiewe opname-navorsingsontwerp is vir die studie gebruik en die respondente was konstruksie-organisasies in Johannesburg, Suid-Afrika. Die studie het 17 beduidende drywers van volhoubare konstruksie geïdentifiseer met konstruksiekoste as die dominante veranderlike. Die belangrike omgewings- (8), ekonomiese (12) en maatskaplike voordele (7) van volhoubare konstruksie is ook bepaal. Die uitdagings (24) van volhoubare konstruksie is ook geïdentifiseer. Die studie het aanbeveel dat maatreëls vir lae konstruksiekoste ingestel moet word, en bewusmakingsveldtogte verbeter moet word. Ekonomiese voordele is steeds agter omgewingsvoordele en dit kan sommige voornemende gebruikers raak. Gebrek aan kennis en swak ekonomieë was algemene uitdagings wat die behoefte aan Westerse ondersteuning vir Afrika-lande beklemtoon om gemaklik volhoubare konstruksie aan te neem.


Sleutelwoorde: Drywer, effek, faktore, konstruksie, projek, Suid-Afrika, uitdagings, volhoubaarheid, volhoubare konstruksie, voordeel

# 1. INTRODUCTION

Worldwide, the construction industry generates more pollutants compared to industries such as manufacturing, banking, telecommunication, and agriculture, with debilitating effects on the environment (Calautit & Hughes, 2016: 1). The impact of the unsustainable activities of the construction industry on environmental degradation was put at 15% of freshwater resources, 40% of the world's energy, and 23%-40% of the world's greenhouse gas emissions (Dosumu & Aigbavboa, 2018: 68). In South Africa, the construction industry accounts for 23% of greenhouse gas emissions, while the production of construction materials results in 18 metric tonnes of carbon dioxide emissions per annum (Simpeh & Smallwood, 2018: 1829). Hence, the construction industry must become aware of the importance of effectively and continuously adopting sustainable construction, in order to reduce the effects of its activities on the environment.

The Green Building Council of South Africa (GBCSA) has adapted the Green Star South Africa rating tool to assess and certify green buildings in South Africa (Sebake, 2008: 29). Despite these steps, the South African construction industry has continually contributed to the negative impacts of unsustainable activities on the environment (Dosumu & Aigbavboa, 2018: 98). As a leading adopter of sustainable construction in Africa, South Africa is still relatively adopting sustainable construction at a low level, despite efforts by government, professional institutions, and the GBCSA to nationwide adoption (Oke & Aigbavboa, 2016: 526). Despite the level of awareness of the concept of sustainable construction by construction professionals, its adoption consistently remains low (Awuzie, Monyane, Koker & Aigbavboa, 2021: 126). This indicates that there are significant factors that are still responsible for this situation. Without proper identification and mitigation of these factors, effective adoption of sustainability in the construction industry may remain a mirage.

Sustainability is a global subject that cuts across virtually all disciplines. How it affects the various sectors of the economy differs from one another (De Vasconcelos, Cãndido & Heineck, 2020: 2). Numerous researches have been conducted across many nations and sectors of national economies on the drivers of sustainability and their effects (Banani, Vahdati, Shahrestani & Clements-Croome, 2016: 289; Veselovská, 2017: 474; Bodkin & Hakimi, 2020: 1). However, the results of the studies indicate that the drivers of sustainability and their effects on the various sectors of the economies differ based on variables such as peculiarity of industries, geographical locations of countries, and level of national development (Harris & Sandor, 2013: 57; Dosumu & Aigbavboa, 2019: 274). Studies have shown that many drivers of sustainable construction mostly differ along with many variables (Marco & James, 2016: 199; Heilman, 2016: 161; Windapo, 2014: 6102).

To achieve the collective and singular aims of sustainable construction, there is a need to conduct a study, specifically for the South African construction industry, on the drivers of sustainable construction and their effects (benefits and challenges) on buildings and the stakeholders (client, contractor, consultants, designers, the occupants, government agencies, and parastatals). Hence, this study investigates the factors influencing the adoption of sustainable construction, the benefits derived from its use, and the challenges mitigating its adoption peculiar to the South African construction industry.

# 2. LITERATURE REVIEW

## 2.1 Sustainable construction

Sustainable construction is the combination of economic, social, and environmental impacts of construction (Heerwagen, 2006: 3; Hwang, Leong & Huh, 2014: 46; Windapo, 2014: 6092). It requires the designers/consultants and contractors to utilise building practices that eradicate negative impacts such as pollution and carbon emission from the environment. Sustainable construction guarantees the preservation of the environment as well as serious development-associated concerns that include efficient use of resources, constant social growth, steady economic growth, and the suppression of poverty (Dosumu & Aigbavboa, 2019: 264). Economic sustainability is the monetary savings of sustainable construction. These savings are primarily gained through reduced utility costs and savings in operations and maintenance (Salama & Hana, 2018: 212). Environmental sustainability implies preserving all living species and ecosystems, as well as ensuring the responsible use of resources (Simpeh & Smallwood, 2018: 1830). Social sustainability focuses on the people occupying a building and on its surroundings (Xia, Zuo, Wu & Ke, 2015: 2).

Sustainability encompasses the conservation of the environment and the efficient use of resources, continual social progress, stable economic growth, and the eradication of poverty (Gibberd, 2010: 36). Currently, human society can continue to meet its needs without hampering the ability of the future human society from meeting its needs on the earth. In the same vein, sustainable construction aims to eradicate the negative effects of construction activities on the environment, while ensuring that the social and economic benefits of construction activities are maximised (De Vasconcelos *et al*., 2020: 28). Many countries worldwide, especially the developed nations, have been reaping the rewards of adopting sustainable construction, even though it is accompanied by a few surmountable challenges. It appears, however, that Africa is continually reluctant or slow in adopting sustainable construction (Dosumu & Aigbavboa, 2020: 5).

## 2.2 Drivers of sustainable construction

Sustainable construction is being adopted and on the increase. However, its current rate of adoption appears not to be on par with the rate of the negative impact of construction activities on the environment. Many factors have been advanced as being responsible for the reluctance and slow adoption of sustainable construction. The cost of sustainable construction has reduced over time, but it is still more expensive than traditional building methods. Depending on the green features and materials to be used, the recovery period can be relatively short or long (Simpeh & Smallwood, 2018: 1831). Acquiring green accreditation could also be cost intensive, time consuming and stressful, regardless of its potential to increase property rental value (Feige, Wallbaum & McAllister, 2013: 324). In addition, the availability and accessibility of sustainable materials and expertise, with sufficient knowledge on sustainable construction, is a key factor to be considered (Ametepey, Aigbavboa & Ansah, 2015: 1686). The surroundings of the proposed building site become another factor that is worth considering. Trees and other buildings could obstruct sunlight, thus decreasing the output of solar systems. Other factors that influence the adoption of sustainable construction include financial and further market-based incentives for sustainability adopters, governmental policies and regulations, and stakeholder participation (Sherwood & Pollard, 2018: 32).

Lam, Chan, Poon, Chau and Chun (2010: 657) classified twenty factors that influence the adoption of sustainable construction into stakeholder's involvement, leadership and responsibility, principles and techniques, as well as feedback and building public confidence. Bamgbade, Kamaruddeen and Nawi (2015: 138) categorised the factors that influence sustainable construction into management, motivating factors, internal resources, external factors, readiness to adopt sustainable construction, supporting resources, and current practices. Enhassi, Kochendoerfer and AlGhoul (2016: 63) highlighted the following: scope and quality of the input of resources, flexibility of design changes to maintenance and variation, estimation of the cost of design and construction, unforeseen inflation in the process of materials for sustainable projects, and the management of the size and complexity of sustainable projects.

Abisuga and Oyekanmi (2014: 115) classified thirteen factors into internal and external factors that influence the adoption of sustainable construction. Kheni and Akoogo (2015: 70) affirmed that the following factors influence the adoption of sustainable construction: awareness of the concept, its relative advantage in business and project use, its compatibility with the client and organisational goals, the complexity of sustainable construction projects, the feasibility of adopting sustainable construction, and the influence of peer companies on a company.

Dosumu and Aigbavboa (2018: 142) investigated the various factors of sustainable construction, as identified in the literature, and classified them into three cardinal categories of economic, social, and environmental factors. Economic factors contain 23 variables that were further divided into cost efficiency, affordability of the project, sustainable construction with minimum cost option, and job creation within the local economy. Social factors include indoor environmental quality of projects, the safety of the people and environment, social and recreational amenities in a building and the community, accessibility to jobs, and amenities by occupants of sustainable projects. Environmental factors include energy generation and consumption, amount of greenhouse carbon emission, water use, efficiency and conservation, material use and efficiency, use of construction land space, waste management, protection and promotion of biodiversity, level of noise and air pollution, and level of dependence on personal car.

Windapo (2014: 6095) categorised the factors of sustainable construction into economic factors (stakeholders' demand and financial issues) and ecological/social responsibility factors (environmental and social responsibility). The results of the study indicated that the key factors of sustainable construction are the industry's Green Star rating system, rising energy costs, legislation, and competitive advantages. Sustainable construction includes ten economic factors, ten political factors, ten social factors, ten technological factors and ten ecological factors (Veselovská, 2017: 478).

It is clear from the literature reviewed in this study that several, almost inexhaustible factors are responsible for the adoption of sustainable construction in the construction industry. This is not unexpected, because the factors responsible for the adoption of sustainable construction vary from one country to the other. These factors were summarised and compressed into 20 and then used for this study to determine the prevalent factors that influence the adoption of sustainable construction in South Africa.

## 2.3 Effects of sustainable construction

This study reviews relevant literature on the effects (benefits and challenges) of adopting sustainability in the construction industry.

### 2.3.1 Benefits of adopting sustainable construction

It is a consensus that the benefits of adopting sustainable construction outweigh those of not adopting it (Waidyasekara & Fernando, 2012: 7). However, the key benefits of its adoption are not global, because they are mostly country and region specific. Many studies investigated the benefits of sustainable construction as they relate to their local economies. In addition, the benefits investigated were mostly lumped rather than categorised into their constituent economic, social, and environmental benefits for easy analyses and understanding. Hence, this study investigates the benefits of sustainable construction based on economic, social, and environmental factors.

The main environmental benefit of sustainable construction is the protection of the ecosystem. This can easily be ensured by incorporating components of landscaping or by sourcing specialist ecologists to determine the specific needs of an area, initiate suitable management techniques, reduce activities that result in loss of habitat, and use species that should be planted in landscaped areas (Ametepey *et al*., 2015: 1687). Reduced carbon emissions that prevent global warming and extreme climate change were also described as environmental benefits of sustainable construction (Vazquez, Rola, Martins, Freitas & Rosa, 2011: 271; Simpeh & Smallwood, 2018: 1845). Environmental benefits of sustainable construction also include minimisation of wastages through recycling, reusing, and reducing waste streams and conservation of water through the water supply, water consumption, and wastewater systems (Ametepey *et al*., 2015: 1688).

Out of 19 environmental benefits investigated by Waidyasekara and Fernando (2012: 10) in Sri Lanka, better air quality inside the facility, reduced energy use, lower fossil fuel use, and the protection of ecological resources were identified as the top four environmental beneficial factors. Lower resource use was the least benefit. Simpeh and Smallwood (2018: 1844) noted that improved air and water quality, reduced waste, conservation, and restoration of natural resources protect biodiversity and ecosystems, and reduce heat gain, particularly when buildings are designed and oriented to optimise the utilisation of daylight.

Dosumu and Aigbavboa (2018: 145) summarised the environmental benefits of sustainable construction into the reduction of greenhouse gas emissions through reduced energy consumption, reduction of air pollution, reduction of solid waste generation through the creation of space for storage and collection of recyclable waste materials, waste management practices on sites, and modular construction techniques, space utilisation in the form of erosion and sedimentation control, reduced lighting disturbances, reduced use of water, and decreased use of fossil and nuclear fuels. Lower potable water use, better air quality inside the facility, reduced energy use, lower fossil fuel use, protection of ecological resources, lower pollution discharges to waterways, reduced air pollution, soil and water conservation, less carbon dioxide emissions, increase in local recycling market, land preservation, and decreased impact of fossil fuel production and distribution were described as the environmental benefits of sustainable construction (Waidyasekara & Fernando, 2012: 10).

Simpeh and Smallwood (2015: 1845) noted that the economic benefits of sustainable construction can also be called financial benefits. However, they also noted concerns about the availability of information on the full benefits of sustainable construction in the South African construction industry. Simpeh and Smallwood (2018: 1845) noted that the economic benefits of sustainable construction are lower operating costs, expansion of markets for sustainable construction, enhancement of occupants' productivity, and optimisation of economic performance beyond the lifetime of a building. Economic benefits can also be regarded as direct benefits, as manifested in energy and water consumption (Oluwunmi, Oladayo, Role & Afolabi, 2019: 9).

According to Liu, Pypłacz, Ermakova and Konev (2020: 6), the economic benefits of sustainable construction are inherent in the integration of green principles into a building's design process. This can lead to roughly 40% further savings and 40% better performance than simply adding green technologies to traditionally designed facilities. Other benefits linked with sustainable construction are reduced energy costs, reduced employee health problems, and increased productivity. Waidyasekara and Fernando (2012: 9) identified lower energy costs, lower annual electricity costs, reduced annual water costs and wastewater costs, as well as lower annual fuel costs as the economic benefits.

Similar to the other types of benefits, the social benefits of sustainable construction have hardly been discussed in the literature, thus making it a herculean task to differentiate the categories to which each of the benefits belongs. Heerwagen (2006: 13) tried to discuss the meaning of social benefits of sustainable construction but failed to itemise the benefits. It was pointed out that a sustainable construction project is not only defined by its environmental, economic, and social benefits, but also in its construction process (Vazquez *et al*., 2011: 272). Simpeh and Smallwood (2018: 1847), however, noted that enhanced comfort, job creation, occupants' health, and aesthetics are some of the social benefits of sustainable construction. Preservation of water resources expanded market for environmentally preferable products, reduced adverse health impacts, improved occupant satisfaction and comfort, increased transportation options for employees, and better occupant comfort satisfaction (Waidyasekara & Fernando, 2012: 12).

Uncategorised benefits of sustainable construction are opportunities for research and development in the construction industry, more tax revenue for the government, climate change-related benefits, reduction of carbon emission, reduction in water and wastewater pumping, as well as reductions in the use of energy. Others include reduction in pollution and environmental degradation, energy efficiency and water conservation, improved indoor air and water quality, protection of biodiversity and ecosystems, minimised strain on local infrastructure, protection of health and comfort, improved quality of life, giving a benchmark for future construction, facilitating a culture of best practice sharing, reduced operational cost, improved occupants' productivity, and reduced utility cost (Oluwunmi *et al*., 2019: 11).

According to Sinha, Gupta and Kutnar (2014: 48), the benefits of sustainable construction are cost-effectiveness, environmentally friendly, natural resources-based, durable, construction healthy habitat for the occupants, preserved livestock, controlled use of resources, reduced dependency, pollution control, and better growth/yield. The Commission for Environmental Cooperation (2008: 65) noted that, in North America, the benefits of green building were estimated by the USGBC to be to reduce energy consumption by 30%, carbon emissions by 35%, water consumption by 30%-50%, and generates waste cost savings of 50%-90%. Sustainable construction promotes stronger societies and provides important benefits to human health and productivity.

Heilman (2016: 134) noted that the many benefits of sustainable construction need to be defined, strategised and identified. This was buttressed by Rahim, Yusoff, Zainon, Wang and Lumpur (2014: 89) who stated that sustainable construction has many benefits, including operational savings, improved use of construction resources, and increased workplace productivity. Hayles and Kooloos (2008: 4) traced the benefits of sustainable construction to reduced energy costs, improved employee health, productivity, boosted company image, and a more pleasant workplace. In the real estate field, sustainable construction gives higher building value, productivity, cost savings, and environmental gains (Liu *et al*., 2020: 7). In view of these, the importance of clarifying the benefits associated with the South African construction industry cannot be overemphasised if its gains are to be maximised.

### 2.3.2 Challenges of sustainable construction

Sustainable construction also has inherent challenges that hamper its effective adoption. Karji, Namian and Tafazzoli (2020: 11) identified financial constraints, inadequate proactive plans, inefficient technology, an insufficient commitment of upper level management, insufficient environmental competencies, lack of awareness among stakeholders, lack of sustainable waste management, lack of workers' training in sustainable operations, management's unwillingness, political impacts, and preferences of suppliers/institutional buyers as the barriers to the effective adoption of sustainable construction in the United States. In Nelson Mandela Bay, it was noted that perceived increased upfront costs, high material costs, minimum standard requirements, and lack of specialist knowledge are the main barriers to the full uptake of sustainable construction (Marco & James, 2016: 196).

The Commission for Environmental Cooperation (2008: 56) advanced the following barriers: separate capital and operating budgets, split incentives, higher perceived/actual first costs, risks and uncertainties, lack of experienced workforce, lack of coordination and consistency in government policies, lack of investment in research, and issues specific to the region. Simpeh and Smallwood (2015: 96) identified the following barriers: capacity barriers, cultural and social resistances, lack of incentives to promote sustainable building, inadequate cost data for sustainable buildings, inadequate information regarding the financial and economic benefits and opportunities of sustainable buildings, limited range of sustainable materials, and delays in obtaining certifications and permits for sustainable buildings.

Among the highly ranked barriers of sustainable construction are poor sustainability education in academic institutions, lack of incentives for designers, ignorance of life-cycle cost benefits, sustainable construction is being less prioritised and other issues take priority, as well as resistance to cultural change in the industry (Toriola-Coker, Alaka, Bello, Ajayi, Adeniyi & Olopade, 2021: 8). The challenges of sustainable construction were classified into external and internal challenges (Awuzie *et al*., 2021: 125). Hayles and Kooloos (2008: 3) noted that, in Australia, lack of accurate data, poverty and low urban investment, stakeholders' lack of interest in sustainability, technological inertia and dependency, lack of integrated research and entrenched colonial codes and standards, lack of knowledge and information on sustainable construction, as well as lack of affordable solutions are major obstacles of sustainable construction. In developing countries such as South Africa, poverty and lack of technologies and materials are the key barriers to sustainable construction.

To this end, it could be stated that the factors, benefits, and barriers to the adoption of sustainable construction are not fixed across countries and regions. This is coupled with the challenge of the obscurity of the benefits, challenges, and drivers of sustainable construction. In the South African construction industry, a great deal of research has been conducted on sustainable construction. These studies did not indicate clearly the benefits, challenges and drivers of sustainable construction. Therefore, this study investigates the drivers of sustainable construction in the construction industry, the benefits, and associated challenges with the effective adoption of sustainable construction.

# 3. RESEARCH METHODOLOGY

## 3.1 Research design

This study adopted the quantitative survey research technique. The survey involved the use of a closed-ended questionnaire because of its ability to allow researchers to generalise their findings from the sample frame (Bryman, 2012: 232). It also allows for descriptive and inferential statistical data analysis (Naoum, 2013: 104). A quantitative research approach supports the use of Likert-type scales to assess data (Netemeyer, Bearden & Sharma, 2003). In this study, the Likert-type survey determined how significant the factors are that define the drivers, benefits, and challenges for adopting sustainable construction. Several data analysis strategies are available. For this study, the mean scores of data were used to calculate the central tendency and to determine the composite (average) score of the Likert-type scale constructs (Nahm, 2016: 9). The mean score ratings were tested with analysis of variance (ANOVA), because the P-values could be extracted (Brereton, 2019: 3). This explains any significant differences in the respondents' opinions on all the factors identified in the study.

## 3.2 Population, sample, and response rate

Sustainable construction is not only a national subject, but it is also global in nature. However, for effectiveness, the study was conducted in Johannesburg (Sandton, Johannesburg, East Rand, Pretoria), South Africa. Johannesburg was selected for the study as it is the capital city and the central business district of Gauteng province, South Africa. Gauteng province is the smallest of the eight provinces in South Africa. However, it accommodates over 25% of the population of the country. In addition, Johannesburg is the largest city in Gauteng province and has a great deal of sustainable construction works such as the Rosebank Link, Commerce Square, Clearwater Office Ark, Cedarwood House, AMR Office Park, 1006 on the Lake Office Building, among others, that can be useful for data collection and analysis.

The population of the study comprised the construction (contracting and consulting) organisations in Johannesburg. Due to the indeterminacy of the exact number of contracting and consulting organisations in Johannesburg, the study obtained a list of registered construction (contracting and consulting) firms (145 building construction firms) in Johannesburg from a reliable website (www.yellowpages.co.za) on the internet. Hence, the population of the study totals 145 building construction firms. The respondents for the study were the professionals (construction managers, quantity surveyors, engineers, and architects) in the construction firms that were used for the study. From the random sample size table of Krejcie and Morgan (1970: 608), the required sample size for a sample frame of 145 is 108. In view of this, a closed-ended questionnaire was sent by hand or by email to the 108 construction organisations that were selected by simple random sampling technique. Hence, 56 copies of the questionnaire, which represent roughly 52% of the sample size for the study were filled in, returned, and used for the study.

Tables 1 and 2 represent the population, sample size distribution and collection of the questionnaire for the study.

Table 1: Population, sample size and response rate by profession of respondents

| *Respondents* | *Population* | *Sample size/questionnaire distributed* | *Returned questionnaire* |
|---|---|---|---|
| Architects | 19 | 14 | 3 |
| Construction managers | 65 | 48 | 33 |
| Engineers | 21 | 16 | 4 |
| Quantity surveyors | 40 | 30 | 16 |
| Total | 145 | 108 | 56 |

Table 2: Population, sample size and response rate by specialisation of firms

| *Respondents* | *Population* | *Sample size/ questionnaire distributed* | *Returned questionnaire* |
|---|---|---|---|
| Consultancy firm | 52 | 39 | 20 |
| Contracting firms | 93 | 69 | 36 |
| Total | 145 | 108 | 56 |

## 3.3 Data collection

The questionnaire for the study was delivered by hand (from January 2021 to March 2021) to selected companies and collected at a later earlier possible date. Some companies received and completed their questionnaire via email. The questionnaire consisted of five sections. The first section, on the respondent's demographic profile, obtained personal information on age, profession/area of specialisation, work experience, academic qualification, and sector of work. The second section set 18 Likert-scale statements for the construct "drivers" that influence the adoption of sustainable construction. Respondents were requested to rate the level of significance on how these factors influence the adoption of sustainable construction. The third section set 28 Likert-scale items on the construct "benefits" of sustainable construction. Respondents were requested to rate the level of importance of each benefit to sustainable construction. Section four set 24 Likert-scale items on the construct "challenges" of sustainable construction. Respondents were requested to rate the level of importance of each statement in hindering the use of sustainable construction systems.

The data from these measurements forms the Likert-scale items used in the descriptive and inferential analysis of this study. To reduce the respondents' bias, closed-ended questions were preferred for sections two to four (Akintoye & Main, 2007: 601).

## 3.4 Data analysis and interpretation of findings

The data for the study was analysed, using the Statistical Package for Social Sciences, version 26. The result of the study was presented with frequencies, percentages, mean scores, interpretation of mean scores, and ranks. The respondents' information was analysed, using descriptive statistics such as frequencies and percentages. The drivers, benefits, and challenges of sustainable construction were analysed by means of mean score, interpretation of mean scores and ranks.

The drivers and the challenges of sustainable construction were analysed, based on the following scale measurements: 1 = Not significant (≥1.00 and ≤1.49); 2 = Slightly significant (≥1.50 and ≤2.49); 3 = Averagely significant (≥2.50 and ≤3.49); 4 = Significant (≥3.50 and ≤4.49), and 5 = Very significant (≥4.50 and ≤5.00). The benefits of sustainable construction were analysed, based on 1 = Not important (≥1.00 and ≤1.49); 2 = Slightly important (≥1.50 and ≤2.49); 3 = Averagely important (≥2.50 and ≤3.49); 4 = Important (≥3.50 and ≤4.49), and 5 = Very important (≥4.50 and ≤5.00).

In determining the internal reliability of the drivers, benefits, and challenges of sustainable construction, Cronbach's *alpha* values were determined in line with Taber (2018: 1279) who stated that the acceptable Cronbach's *alpha* values range from 0.70 to 0.95. In the current study, a cut-off value of 0.80 was preferred.

The analysis of variance (ANOVA) test with $p \leq 0.05$ was done to find any significant differences between the means in the opinions of the six respondent groups on all the factors identified in the study.

## 3.5 Limitation of the study

This study was conducted in the Gauteng province of South Africa which, although suitable for the study, represents only one of the eight provinces in South Africa. This indicates that a similar study may need to be conducted in other regions or countries to confirm or debunk the results of this study. Similarly, the study was limited to building projects. Hence, it may not be readily applicable to civil engineering, oil and gas, telecommunications, and other types of construction projects without carrying out a similar study.

# 4. FINDINGS

## 4.1 Respondents' profile

Table 3 shows the general information of the respondents of the study and their respective organisations. The data collected from the survey indicated that the vast majority (88%) of the respondents are construction/project managers (59%) or quantity surveyors (29%) and work in the private sector (92%). Analysis of the respondents' academic qualification showed that the majority of the respondents have either a first degree (45%) or a PhD degree (37%); only 5% of the respondents have a Masters' degree. Half (50%) of the respondents are aged between 31 to 50 years, and over half (53%) of the respondents have six years' professional experience or more.

Table 3: Respondents' profile

| *Characteristic* | *Category* | *Frequency (N = 56)* | *%* |
|---|---|---|---|
| Age (years) | 21-25 | 6 | 11 |
| | 26-30 | 12 | 21 |
| | 31-35 | 9 | 16 |
| | 36-40 | 10 | 18 |
| | 41-45 | 2 | 3 |
| | 46-50 | 7 | 13 |
| | 51-55 | 3 | 5 |
| | 56 and above | 7 | 13 |

| *Characteristic* | *Category* | *Frequency (N = 56)* | *%* |
|---|---|---|---|
| Profession | Architect | 3 | 5 |
| | Engineer | 4 | 7 |
| | Construction/Project managers | 33 | 59 |
| | Quantity surveyor | 16 | 29 |
| Work experience (years) | Less than 1 year | 15 | 26 |
| | 1-2 | 3 | 5 |
| | 3-5 | 9 | 16 |
| | 6-10 | 7 | 13 |
| | 11-15 | 10 | 18 |
| | 16-20 | 6 | 11 |
| | 21-25 | 2 | 3 |
| | Above 25 | 4 | 8 |
| Academic qualification | Diploma | 7 | 13 |
| | Bachelor's degree | 25 | 45 |
| | Master's degree | 3 | 5 |
| | Doctorate degree | 21 | 37 |
| Sector of work | Private | 52 | 92 |
| | Public | 4 | 8 |

These characteristics imply that the respondents have adequate education and experience to give substantial information that could help in making useful inferences and deductions on factors influencing the adoption of sustainable construction.

## 4.2 Drivers of sustainable construction

Table 4 ranks the factors influencing the adoption of sustainable construction (drivers) in the construction industry. The Cronbach *alpha* value was greater than 0.70 at 0.84, indicating acceptable internal reliability of the factors, as recommended by Taber (2018: 1279). With an average MS of 3.95, the respondents indicated that all factors significantly influence the adoption of sustainable construction in the construction industry, except for strategic planning, concept planning and project programming, and availability of institutional framework for effective implementation that were averagely significant. The study also indicated that there is no factor that 'very significantly' influences the adoption of sustainable construction.

Table 4: Factors influencing the adoption of sustainable construction in the construction industry

| | *Descriptive statistics (N = 59) Cronbach's alpha 0.84* | | | *Inferential statistics ANOVA* | |
|---|---|---|---|---|---|
| *Factor* | *MS* | *Rank* | *Remark* | *F value* | *P-value Sig.* |
| Construction costs | 4.47 | 1 | Significant | 3.420 | 0.031* |
| Accessibility to resources, especially sustainable materials | 4.34 | 2 | Significant | 8.525 | 0.001* |
| Basic knowledge of sustainable construction | 4.26 | 3 | Significant | 6.127 | 0.004* |
| Government policies and regulations (e.g., tax and incentives of sustainable construction) | 4.16 | 4 | Significant | 4.680 | 0.011* |
| Efficiency of wind energy systems | 4.15 | 5 | Significant | 3.608 | 0.026* |
| Suitability of intended project area to maximise usage of sustainable construction | 4.11 | 6 | Significant | 1.933 | 0.154 |
| Efficiency of solar energy systems | 4.11 | 6 | Significant | 12.578 | 0.001* |
| Climate conditions of intended project area (number of hours of sunshine in a day for solar panels) | 4.08 | 8 | Significant | 15.163 | 0.001* |
| Availability of financial and market-based incentives for adopters of sustainability | 4.05 | 9 | Significant | 11.870 | 0.001* |
| Green rating system and its criteria | 4.05 | 9 | Significant | 15.053 | 0.001* |
| Financial approval of sustainable project | 4.03 | 11 | Significant | 5.363 | 0.006* |
| Reliability of sustainable resources | 3.95 | 12 | Significant | 18.558 | 0.001* |
| Stakeholders' level of participation in sustainable construction | 3.95 | 12 | Significant | 6.968 | 0.002* |
| Availability of independent expertise to develop and design sustainable buildings | 3.89 | 14 | Significant | 6.180 | 0.004* |
| Accessibility to sustainable builders' services | 3.84 | 15 | Significant | 10.845 | 0.001* |
| Efficiency of hydro-energy systems | 3.65 | 16 | Significant | 7.783 | 0.001* |
| Strategic planning, concept planning, and project programming | 3.45 | 17 | Averagely significant | 2.307 | 0.090 |
| Availability of institutional framework for effective implementation | 2.61 | 18 | Averagely significant | 7.597 | 0.002* |
| Average MS (composite score) | 3.95 | | | | |

Note: * indicates a statistically significant difference between respondent groups, $p \leq 0.05$

Respondents rated construction cost (MS 4.47), accessibility to resources (MS 4.34), basic knowledge of sustainable construction (MS 4.26), government policies and regulations (MS 4.16), and efficiency of wind-energy systems (MS 4.26) as the top five factors that significantly influence the adoption of sustainable construction.

The ANOVA results indicate that there is a significant difference ($p \leq 0.005$) in the respondents' opinions on the ranking of the significance of the drivers identified in the study, except for suitability of intended project area to maximise the usage of sustainable construction (p 0.154), and strategic planning, concept planning and project programming (p 0.090). This means that all the respondents did not agree on the order of significance of 16 out of the 18 factors that influence the adoption of sustainable construction in South Africa.

## 4.3 Effects of adopting sustainable construction

### 4.3.1 Benefits

Table 5 shows the individual and the combined (environmental, economic, and social) benefits of sustainable construction. The Cronbach *alpha* value was greater than 0.70 at 0.84, indicating acceptable internal reliability of the factors, as recommended by Taber (2018: 1279).

With an average MS of 4.33, respondents indicated that all environmental benefits are important for sustainable construction in the construction industry. Among the eight environmental benefits investigated in the study, respondents rated conservation of natural resources (MS 4.61), reduction in wastage of water (MS 4.61), and reduction of waste (MS 4.50) as being very important. With an average MS of 3.80, respondents indicated that all economic benefits are important for sustainable construction in the construction industry. None of the economic benefits was very important to the respondents of the study. Respondents rated more revenue opportunities (MS 4.18), utilities savings (MS 3.92), maintenance savings (MS 3.92), special tax incentives (MS 3.89), and improvement of occupants' productivity (MS 3.87) as the top five economic benefits of sustainable construction. Improvement of the lifespan of buildings was rated as an averagely important economic benefit of sustainable construction.

With an average MS of 3.75, respondents indicated that all social benefits are important for sustainable construction in the construction industry. Eight social benefits were elicited for the study and seven of them were rated as being important. The last social benefit was rated as being averagely important. The top five social benefits of sustainable construction as rated by respondents are improvement of the quality of life (MS 4.16),

Table 5: Benefits of sustainable construction

| | | *Descriptive statistics (N = 59) Cronbach's alpha 0.84* | | | | | | *Inferential statistics ANOVA* | |
|---|---|---|---|---|---|---|---|---|---|
| *Benefits* | *Category* | *Category MS* | *Category rank* | *Category remark* | *Overall MS* | *Overall rank* | *Overall remark* | *F value* | *P-value Sig.* |
| Conserve natural resources | Environmental | 4.61 | 1 | Very important | 4.61 | 1 | Very important | 8.004 | 0.001* |
| Reduce wastage of water | Environmental | 4.61 | 1 | Very important | 4.61 | 1 | Very important | 10.719 | 0.009* |
| Waste reduction | Environmental | 4.50 | 3 | Very important | 4.50 | 3 | Very important | 13.281 | 0.003* |
| Improve air and water quality | Environmental | 4.37 | 4 | Important | 4.37 | 4 | Important | 4.218 | 0.015* |
| Protect biodiversity and ecosystems | Environmental | 4.18 | 5 | Important | 4.18 | 5 | Important | 20.508 | 0.010* |
| Climate regulation | Environmental | 4.18 | 5 | Important | 4.18 | 5 | Important | 5.431 | 0.009* |
| More revenue opportunities | Economic | 4.18 | 1 | Important | 4.18 | 5 | Important | 22.904 | 0.001* |
| Minimise noise pollution | Environmental | 4.16 | 7 | Important | 4.16 | 8 | Important | 9.217 | 0.001* |
| Improve quality of life | Social | 4.16 | 1 | Important | 4.16 | 8 | Important | 6.137 | 0.006* |
| Temperature control | Environmental | 4.00 | 8 | Important | 4.00 | 10 | Important | 11.660 | 0.001* |
| Minimise strain on local infrastructure | Social | 3.97 | 2 | Important | 3.97 | 11 | Important | 11.660 | 0.001* |
| Utilities savings | Economic | 3.92 | 2 | Important | 3.92 | 12 | Important | 2.105 | 0.141 |
| Maintenance savings | Economic | 3.92 | 2 | Important | 3.92 | 12 | Important | 12.031 | 0.001* |
| Improve occupant health and comfort | Social | 3.92 | 3 | Important | 3.92 | 12 | Important | 7.700 | 0.002* |
| Special tax incentives | Economic | 3.89 | 4 | Important | 3.89 | 15 | Important | 2.188 | 0.130 |
| Improve occupant productivity | Economic | 3.87 | 5 | Important | 3.87 | 16 | Important | 1.727 | 0.209 |

| | | *Descriptive statistics (N = 59) Cronbach's alpha 0.84* | | | | | | *Inferential statistics ANOVA* | |
|---|---|---|---|---|---|---|---|---|---|
| ***Benefits*** | ***Category*** | ***Category MS*** | ***Category rank*** | ***Category remark*** | ***Overall MS*** | ***Overall rank*** | ***Overall remark*** | ***F value*** | ***P-value Sig.*** |
| Reduce operating costs | Economic | 3.81 | 6 | Important | 3.81 | 17 | Important | 5.542 | 0.009* |
| Allow for competitive tendering | Economic | 3.81 | 6 | Important | 3.81 | 17 | Important | 20.508 | 0.001* |
| Increase of property value | Economic | 3.79 | 8 | Important | 3.79 | 19 | Important | 5.431 | 0.009* |
| Optimises the life cycle of the building | Economic | 3.76 | 9 | Important | 3.76 | 20 | Important | 22.904 | 0.001* |
| Create an aesthetically pleasing environment | Social | 3.76 | 4 | Important | 3.76 | 20 | Important | 9.217 | 0.001* |
| Create market for green product and services | Economic | 3.74 | 10 | Important | 3.74 | 22 | Important | 6.137 | 0.006* |
| Increases occupants' overall moral | Social | 3.68 | 5 | Important | 3.68 | 23 | Important | 11.660 | 0.001* |
| Green systems accreditation | Economic | 3.66 | 11 | Important | 3.66 | 24 | Important | 11.660 | 0.001* |
| Improves worker productivity | Social | 3.66 | 6 | Important | 3.66 | 24 | Important | 2.105 | 0.141 |
| 'Feel good' concept of satisfaction in using and adopting green systems | Social | 3.55 | 7 | Important | 3.55 | 26 | Important | 12.031 | 0.001* |
| Connection to nature | Social | 3.32 | 8 | Averagely important | 3.32 | 27 | Averagely important | 7.700 | 0.002* |
| Improve building lifespan | Economic | 3.29 | 12 | Averagely important | 3.29 | 28 | Averagely important | 2.188 | 0.130 |
| Average MS (composite score) | Environmental (4.33); Economic (3.80); Social (3.75) | | | | 3.96 | | | | |

Note: * indicates a statistically significant difference between respondent groups, $p \leq 0.05$

minimisation of strain on local infrastructure (MS 3.97), improvement of occupants' health and comfort (MS 3.92), create an aesthetically pleasing environment (MS 3.76), and increase in occupants' overall morale (MS 3.68). Connection to nature (MS 3.32) was rated as an averagely important social benefit of sustainable construction.

For the combined (environmental, economic, and social) benefits of sustainable construction, three out of the 28 combined benefits investigated in the study were found to be very important, two were found to be averagely important, and the remainder were found to be important. The top four benefits of sustainable construction as rated by respondents are all environmental benefits: conservation of natural resources (MS 4.16), reduction of wastage of water (MS 4.16), reduction of waste (MS 4.50), improved air and water quality (MS 4.37), as well as protection of biodiversity and ecosystems (MS 4.18). Except for connection to nature and improvement of a building's lifespan being rated as averagely important, the remaining benefits were rated as important.

The ANOVA results indicate that there is a significant difference ($p \leq 0.005$) in the respondents' opinions on the ranking of the importance of the benefits identified in the study, except for utilities savings (p 0.141), special tax incentives (p 0.130), improvement of occupants' productivity (p 0.209), improves worker productivity (p 0.141), and building's lifespan (p 0.130). This means that the respondents did not agree on the order of importance of 23 out of the 28 benefits of sustainable construction in South Africa.

### 4.3.2 Challenges

Table 6 indicates the challenges with the adoption of sustainable construction. With an average MS of 3.55, the respondents indicated that all challenges significantly hinder the use of sustainable construction systems.

The Cronbach *alpha* value was greater than 0.70 at 0.86, indicating acceptable internal reliability of the factors, as recommended by Taber (2018: 1279). One out of the 27 challenges investigated in the study was rated as being very significant and the remaining were rated as significant. Hence, the top five challenges that hinder the adoption of sustainable construction are lack of knowledge on sustainable systems (MS 4.53), weakness of the economy (MS 4.39), lack of government incentives in the private sector (MS 4.26), lack of finances to attain sustainable materials (MS 4.24), as well as monetary and budget boundaries (MS 4.24).

Table 6: Challenges of sustainable construction

| | *Descriptive statistics (N = 59) Cronbach's alpha 0.86* | | | *Inferential statistics ANOVA* | |
|---|---|---|---|---|---|
| *Factors hindering the use of sustainable construction systems* | *MS* | *Rank* | *Remark* | *F value* | *P-value Sig.* |
| Lack of knowledge on sustainable systems | 4.53 | 1 | Very Significant | 0.619 | 0.556 |
| A weak economy | 4.39 | 2 | Significant | 7.219 | 0.010* |
| Lack of government incentives in the private sector | 4.26 | 3 | Significant | 10.669 | 0.035* |
| Lack of finances to attain sustainable materials | 4.24 | 4 | Significant | 1.430 | 0.072 |
| Monetary and budget boundaries | 4.24 | 4 | Significant | 13.208 | 0.008* |
| Lack of government incentives in public sector | 4.18 | 6 | Significant | 8.125 | 0.046* |
| Lack of monitoring operations | 4.16 | 7 | Significant | 12.315 | 0.034* |
| Lack of innovation | 4.16 | 7 | Significant | 11.520 | 0.026* |
| Lack of finances to attain sustainable systems | 4.08 | 9 | Significant | 2.888 | 0.481 |
| Lack of stakeholder participation | 4.05 | 10 | Significant | 13.130 | 0.025* |
| Lack of compulsory green system accreditation requirements | 4.00 | 11 | Significant | 12.610 | 0.042* |
| Lack of innovative sustainable materials i.e., reusable concrete | 3.97 | 12 | Significant | 12.340 | 0.025* |
| Lack of financial viability | 3.94 | 13 | Significant | 11.520 | 0.026* |
| Lack of sustainable construction technology | 3.92 | 14 | Significant | 11.880 | 0.016* |
| Lack of set targets of implemented sustainable construction systems | 3.89 | 15 | Significant | 11.560 | 0.021* |
| Lack of sustainable construction processes | 3.89 | 15 | Significant | 0.476 | 0.634 |
| Lack of social viability | 3.86 | 17 | Significant | 5.163 | 0.011* |
| Lack of finances to attain an accredited sustainable builder | 3.84 | 18 | Significant | 2.690 | 0.062 |
| Lack of stakeholder participation | 3.78 | 19 | Significant | 8.061 | 0.002* |
| Resource scarcity | 3.78 | 19 | Significant | 5.785 | 0.007* |
| Lack of hydro-energy systems | 3.76 | 21 | Significant | 4.155 | 0.023* |
| Lack of environmental viability | 3.73 | 22 | Significant | 2.322 | 0.114 |
| Lack of efficient wind-energy systems | 3.73 | 22 | Significant | 13.331 | 0.001* |
| Lack of efficient solar energy systems | 3.73 | 24 | Significant | 12.570 | 0.001* |
| Average MS (composite score) | 3.55 | | | | |

Note: * indicates a statistically significant difference between respondent groups, $p \leq 0.05$

The ANOVA results indicate that there is a significant difference ($p \leq 0.005$) in the respondents' opinions on the ranking of the factors that hinder the adoption of sustainable construction in South Africa, except for the lack of knowledge on sustainable systems (p 0.556), lack of finances to attain sustainable materials (p 0.130), lack of finances to attain sustainable systems (p 0.481), lack of sustainable construction processes (p 0.634), lack of finances to attain an accredited sustainable builder (p 0.062), and lack of environmental viability (p 0.114). This means that the respondents did not agree on the ranking order of significance on 18 out of the 24 challenges of sustainable construction in South Africa. The reasons for the differences in the respondents' opinions on the factors that hinder the adoption of sustainable construction are not investigated in this study and hence not clear. There may be a need to conduct further investigation into the reasons for the differences in perception.

# 5. DISCUSSION OF FINDINGS

The study investigated the drivers and the effects (benefits and challenges) of adopting sustainable construction in the construction industry.

## 5.1 Drivers of sustainable construction

The results indicated that the cost of construction is the topmost driver for the adoption of sustainable construction. This means that sustainable construction would not be practised if the construction cost is too high for the client to bear. In addition, sustainable construction depends on the ease of accessing human resources and sustainable materials. The level of knowledge of sustainable construction was found to be a significant driver of the adoption of sustainability in the construction industry.

Other significant drivers in the study include government policies and regulations concerning sustainable construction, efficiency of wind-energy systems, suitability of the area of construction for sustainable projects, efficiency of solar system, weather conditions, availability of market incentives for adopters, the criteria for green rating and the system adopted, financial approval for sustainable projects, level of confidence in sustainable resources such as materials, availability of human capacity to design sustainable building, availability of sustainable construction contractors, and efficiency of hydro-energy systems.

A critical look at these drivers indicates that, even though some factors may be worked upon in favour of the successful adoption of sustainable construction, other drivers may naturally hamper the adoption of sustainable construction and may not be easily overcome. These factors include efficiency of wind systems (to prevent the use of fans and air conditioners), efficiency of solar-energy system, climate condition in the area of construction (lack of adequate solar energy to power a building and its appliances), and efficiency of hydro-energy system (for adequate availability and use of water). Hence, in areas where the natural drivers are prevalent, concerted efforts may need to be made towards the successful adoption of sustainable construction.

This study discovered that 16 out of the numerous drivers of sustainable construction, which are discussed in literature, are significant for the South African construction industry. The significant drivers identified in this study are consistent with the studies of  Simpeh and Smallwood (2018: 183), on construction cost; Tabassi *et al*. (2016: 728), on green building rating system; Ametepey *et al*. (2015: 1686), as well as Kheni and Akoogo (2015: 69), on poor sunlight for powering solar systems and fundamental knowledge and awareness of sustainable construction, and Sherwood and Pollard (2018)as well as the potential for risk diversification through investments in emerging markets. This study evaluated literature on investing in both emerging markets and integrating environmental, social, and governance (ESG on poor governmental policies and regulations and lack of financial and market incentives for adopters of sustainable construction. Further inferential statistics indicate that, even though the respondents of the study did not agree on the order of significance on most of the factors that influence the adoption of sustainable construction, they agreed on suitability of intended project area to maximise the usage of sustainable construction, as well as strategic planning, concept planning and project programming as being significant factors for the adoption of sustainable construction.

## 5.2 Effects of adopting sustainable construction

The effects include the benefits and the challenges of adopting sustainability in the construction industry.

### 5.2.1 Benefits

Similarly, many benefits of adopting sustainable construction have been advanced in literature. However, this study identified three benefits of sustainable construction as being very important and 23 as being important. It is important to affirm that the benefits of sustainable construction that were very important (conservation of natural resources, reduction of water wastages, and waste reduction) fall under the environmental benefits. It is also important to state that all the environmental benefits of sustainable construction fall within the first ten benefits of the 26 combined (environmental, economic, and social) benefits investigated.

In addition, the top six benefits (conservation of natural resources, reduction of water wastages, waste reduction, improvement of air and water quality, protection of biodiversity and ecosystems, and climate regulation) of the 26 combined benefits investigated in the study were environmental benefits of sustainable construction. Improvement of the quality of life, minimisation of strain on local infrastructure, and improvement of occupants' health and comfort were the top three social benefits of sustainable construction and ranked as 8$^{th}$, 11$^{th}$, and 12$^{th}$ benefits, respectively. In the same vein, the top economic benefits of sustainable construction were more revenue opportunities, utilities savings and maintenance savings, ranked as 5$^{th}$ and 12$^{th}$, respectively.

To summarise this analysis. Sustainability seems to be more entrenched in environmental preservation than the social and economic values they give. Hence, this result is not unexpected, because the thrust of sustainability and sustainable construction is to preserve the environment such that natural resources are not further depleted, thus preventing continuous carbon emission and climate change. In general, the result of this study agrees with the studies of Simpeh and Smallwood (2018: 1845), Dosumu and Aigbavboa (2018: 145), Waidyasekara and Fernando (2012: 10), Sinha et al. (2014: 48) and Liu et al. (2020: 7). In addition, the analysis of variance on the benefits of adopting sustainable construction indicates that the respondents agreed on utilities savings, special tax incentives, improvement of occupants' productivity, and building's lifespan.

### 5.2.2 Challenges

The results of the study further indicate that lack of knowledge on sustainable system is a very significant challenge of sustainable construction. Other challenges such as weak economy, lack of government incentives and regulations, lack of money to acquire sustainable materials, lack of monitoring operation, and lack of innovation were found to be significant challenges of sustainable construction. Dosumu and Aigbavboa (2018: 142) particularly identified lack of awareness of sustainable construction and technology as the bane of the adoption of sustainable construction in Africa.

Hence, the findings of this study on the challenges of adopting sustainable construction are consistent with the findings of Karji et al. (2020: 11) on lack of awareness among stakeholders, lack of compulsory green system accreditation requirements, and lack of innovative sustainable materials. Similarly, the study agrees with Marco and James (2016: 196) as well as with Hayles and Kooloos (2008: 3) on lack of specialists' knowledge, capacity barriers, poverty and low urban investment, technological inertia and dependency, lack of knowledge and information on sustainable construction. Lastly, the study agrees with Simpeh and Smallwood (2015: 96) on lack of incentives to promote sustainable building, inadequate information regarding the financial and economic benefits and opportunities of sustainable buildings, limited range of sustainable materials, and delays in obtaining certifications and permits for sustainable buildings. The findings of the study also indicate that the respondents agreed on lack of knowledge on sustainable systems, lack of finances to attain sustainable materials, lack of finances to attain sustainable systems, lack of sustainable construction processes, lack of finances to attain an accredited sustainable builder, and lack of environmental viability as challenges to the adoption of sustainable construction system.

## 6. CONCLUSION

The study investigated the drivers and effects of adopting sustainable construction. Based on its findings, the study concluded that the cost of sustainable construction is the topmost factor considered for its adoption. In addition, the availability of human resources and sustainable materials hampers the adoption of sustainable construction. Lack of knowledge of sustainable construction is significant to the adoption of sustainable construction. Other drivers of sustainable construction are government policies, weather condition, and market incentives. Furthermore, the study concluded that there are natural drivers of sustainable construction that can hamper sustainable construction and require further efforts for successful adoption.

Conservation of natural resources, reduction of water wastages, and waste reduction are the most significant benefits of adopting sustainable construction. The environmental benefits of sustainable construction are at the top (above social and economic benefits) of all the benefits of sustainable construction. The top social benefits of sustainable construction are improvement of the quality of life, minimisation of strain on local infrastructure, and improvement of occupants' health and comfort. The top economic benefits of sustainable construction are revenue opportunities, utilities savings, and maintenance savings. Hence, the study concluded that environmental preservation is the thrust of sustainability above the social and economic values. Lastly, the study concluded that lack of knowledge on sustainable system, weak economy or poverty, lack of government incentives and regulations, lack of money to acquire sustainable materials, and lack of monitoring operation and innovation are the top challenges with the adoption of sustainable construction.

Based on the conclusions of the study, it is recommended that construction stakeholders need to develop a mechanism for overcoming the natural factors that hamper the adoption of sustainable construction. Government also needs to create an enabling environment for the practice of sustainable construction through favourable policies and regulations. These regulations would go a long way in mitigating challenges such as market and financial incentives, availability of sustainable materials, cost of sustainable construction, and certification for green buildings. Awareness through educational institutions, professional bodies, and conferences needs to be done so that the adoption of sustainable construction can be encouraged and improved.

## REFERENCES

Abisuga, A. & Oyekanmi, O. 2014. Organizational factors affecting the usage of sustainable building materials in the Nigerian construction industry. *Journal of Emerging Trends in Economics Management Science,* 5(2), pp. 113-119.

Akintoye, A. & Main, J. 2007. Collaborative relationships in construction: The UK contractor's perception. *Engineering, Construction and Architectural Management*, 14(6), pp. 597-617. http://dx.doi.org/10.1108/09699980710829049

Ametepey, O., Aigbavboa, C. & Ansah, K. 2015. Barriers to successful implementation of sustainable construction in the Ghanaian construction industry. *Procedia Manufacturing*, vol. 3, pp. 1682.1689. https://doi.org/10.1016/j.promfg.2015.07.988

Awuzie, B.O., Monyane, T.G., Koker, C. & Aigbavboa, C. 2021. Evaluation of factors influencing environmental sustainability performance of construction projects in South Africa. *Sustainability and Climate Change*, 14(2), pp. 122-132. https://doi.org/10.1089/scc.2020.0044

Bamgbade, J., Kamaruddeen, A. & Nawi, M. 2015. Factors influencing sustainable firms in Malaysia: A preliminary study using PLS-SE. *Technical Journal of the Faculty of Engineering* (*TJFE*), 38(3), pp. 132-142.

Banani, R., Vahdati, M.M., Shahrestani, M. & Clements-Croome, D. 2016. The development of building assessment criteria framework for sustainable non-residential buildings in Saudi Arabia. *Sustainable Cities and Society*, vol. 26, pp. 289-305. https://doi.org/10.1016/j.scs.2016.07.007

Bodkin, A. & Hakimi, S. 2020. Sustainable by design: A systematic review of factors for health promotion program sustainability. *BMC Public Health*, 20(1), pp. 1-16. https://doi.org/10.1186/s12889-020-09091-9

Brereton, R.G. 2019. ANOVA tables and statistical significance of models. *Journal of Chemometrics*, 33(1), pp. 1-5. https://doi.org/10.1002/cem.3019

Bryman, A. 2012. *Social research methods*. 4th edition. New York: Oxford University Press.

Calautit, J.K. & Hughes, B.R. 2016. Sustainable buildings: Opportunities, challenges, aims and vision. *Sustainable Buildings*, vol. 1, pp. 1-4. https://doi.org/10.1051/sbuild/2016001

Commission for Environmental Cooperation. 2008. *Green building in North America: opportunities and challenges: Secretariat report to Council under Article 13 of the North American Agreement on Environmental Cooperation*. Montréal, Québec: Commission for Environmental Cooperation.

De Vasconcelos, I.A., Cãndido, L.F. & Heineck, L.F. 2020. Evaluation of sustainable construction sites: A lean, green and well-being integrated approach. *Gestao e Producao*, 27(3), pp. 17-32. https://doi.org/10.1590/0104-530x4552-20

Dosumu, O.S. & Aigbavboa, C. 2018. *Sustainable design and construction in Africa: A system dynamic approach*. Abingdon-on-Thames, UK: Routlege. https://doi.org/10.1201/9781351212205

Dosumu, O.S. & Aigbavboa, C. 2019a. An investigation of the benefits and challenges of adopting alternative building materials (ABM) in the construction industry. In: Peng Wu, P. & Wang, Z. (Eds). *Innovative production and construction,* pp. 261-277. World Scientific. https://doi.org/10.1142/9789813272491_0016

Dosumu, O.S. & Aigbavboa, C.O. 2019b. An Investigation of the factors influencing indoor environmental quality (IEQ) of residential buildings in Gauteng, South Africa. *Periodica Polytechnica Architecture*, 50(1), pp. 81-88. https://doi.org/10.3311/ppar.12789

Dosumu, O.S. & Aigbavboa, C. 2020. An investigation of the barriers to the uptake of local materials in Africa: A literature review approach. *African Journal of Science, Technology, Innovation and Development*, 12(4), pp. 1-19. https://doi.org/10.1080/20421338.2019.1654251

Enhassi, A., Kochendoerfer, B. & AlGhoul, H. 2016. Factors affecting sustainable performance of construction projects during project life cycle phases. *International Journal of Sustainable Construction Engineering and Technology*, 7(1), pp. 50-68.

Feige, A., Mcallister, P., Wallbaum, H. 2013. Rental price and sustainability ratings: Which sustainability criteria are really paying back? *Construction Management and Economics*, 31(4), pp. 322-334. https://doi.org/10.1080/01446193.2013.769686

Gibberd, J. 2010. Sustainable development criteria for built environment projects in South Africa (CSIR). *Human Settlements Review*, 1(1), pp. 34-58.

Harris, N. & Sandor, M. 2013. Defining sustainable practice in community-based health promotion: A Delphi study of practitioner perspectives. *Health Promotion Journal of Australia*, 24(1), pp. 53-60. https://doi.org/10.1071/HE12908

Hayles, C.S. & Kooloos, T. 2008. The challenges and opportunities for sustainable building practices. Paper presented at the CIB W107 Construction in Developing Countries International Symposium, 16-18 January, Trinidad & Tobago, West Indies, pp. 1-9.

Heerwagen, J.H. 2006. Investing in people: The social benefits of sustainable design. Working Paper, Rethinking Sustainable Construction '06, Sarasota, FL., pp. 19-22.

Heilman, V.M. 2016. Factors hindering the adoption of sustainable design and construction practices : The case of office building development in Dar es Salaam, Tanzania. PhD thesis. Faculty of Architecture and Urban Planning, University of Stuttgart, Germany.

Hwang, B.G., Leong, L.P. & Huh, Y.K. 2014. Sustainable green construction management: Schedule performance and improvement. *Technological and Economic Development of Economy*, 19(1), pp. S43-S57. https://doi.org/10.3846/20294913.2013.869669

Karji, A., Namian, M. & Tafazzoli, M. 2020. Identifying the key barriers to promote sustainable construction in the United States: A principal component analysis. *Sustainability*, 12(2), pp. 1-20. https://doi.org/10.3390/su12125088

Kheni, N.A. & Akoogo, M.A. 2015. Determinants of sustainable construction practices in Ghana using structural equation modeling. *Journal of Sustainable Development,* 8(3), pp. 67-78. https://doi.org/10.5539/jsd.v8n3p67

Krejcie, R.V. & Morgan, D.W. 1970. Determining sample size for research activities. *Educational and Psychological Measurement*, vol. 30, pp. 607-610. https://doi.org/10.1177/001316447003000308

Lam, P.T., Chan, E.H., Poon, C.S., Chau, C.K. & Chun, K.P. 2010. Factors affecting the implementation of green specifications in construction. *Journal of Environmental Management*, vol. 91, pp. 654-661. https://doi.org/10.1016/j.jenvman.2009.09.029

Liu, Z.J., Pypłacz, P., Ermakova, M. & Konev, P. 2020. Sustainable construction as a competitive advantage. *Sustainability*, 12(15), pp. 1-13. https://doi.org/10.3390/SU12155946

Marco, Z. & James, C. 2016. *The perceived barriers to the construction of green buildings in Nelson Mandela Bay, South Africa*. Paper presented at the 9th cidb Postgraduate Conference on Emerging Trends in Construction Organisational Practices and Project Management Knowledge Area, 2-4 February, Cape Town, South Africa.

Nahm, F.S. 2016. Nonparametric statistical tests for the continuous data: The basic concept and the practical use. *Korean Journal of Anesthesiology*, 69(1), pp. 8-14. DOI:http://doi.org/10.4097/kjae.2016.69.1.8

Naoum, S.G. 2013. *Dissertation research and writing for construction students.* 3rd edition. Oxford: Butterworth-Heinemann. https://doi.org/10.4324/9780080467047

Netemeyer, R.G., Bearden, O.E. & Sharma, S. 2003. *Scaling procedures: Issues and applications*. Thousand Oaks, CA: Sage. http://doi.org/10.4135/9781412985772

Oke, A. & Aigbavboa, C. 2016. Influences of sustainable construction practices in South Africa. In: *Proceedings of the SBE16 SEOUL International Conference on the Sustainble Built Environment*, 12-14 December, Seoul, South Korea, pp. 525-529.

Oluwunmi, A.O., Oladayo, O.P., Role, B.A. & Afolabi, T.O. 2019. Benefits and barriers to the implementation of green building standards in universities: What are students' views? *IOP Conference Series: Materials Science and Engineering*, 640(1), pp. 1-12. https://doi.org/10.1088/1757-899X/640/1/012031

Rahim, F.A., Yusoff, N.S., Zainon, N., Wang, C. & Lumpur, K. 2014. Sustainable construction through life cycle costing. *Journal of Building Performance*, 5(1), pp. 84-94.

Salama, M. & Hana, A. 2018. Chapter 9 Sustainable construction, green building strategic model. In: Salama, M. (Ed.). Oxford: Goodfellow Publishers, pp. 212-239. http://dx.doi.org/10.23912/9781911396857-3966

Sebake, N. 2008. Overview of green building rating tools. In: Van Wyk, L. (Ed.). *Green building handbook South Africa,* Vol. 1. Cape Town: alive2green 2010, pp. 27-34.

Sherwood, M.W. & Pollard, J.L. 2018. The risk-adjusted return potential of integrating ESG strategies into emerging market equities. *Journal of Sustainable Finance and Investment*, 8(1), pp. 26-44. https://doi.org/10.1080/20430795.2017.1331118

Simpeh, E.K. & Smallwood, J.J. 2015. Factors Influencing the growth of green building in the South African construction industry. In: Gibberd, J. & Conradie, D. (Eds). *Proceedings of the Smart and Sustainable Built Environment (SASBE) Conference*, 9-11 December, vol. 2. Pretoria, South Africa: CIB & CSIR, pp. 93-99.

Simpeh, E.K. & 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.

Sinha, A., Gupta, R. & Kutnar, A. 2014. Sustainable development and green buildings. *Drvna Industrija,* 64(1), pp. 45-53. https://doi.org/10.5552/drind.2013.1205

Tabassi, A.A., Argyropoulou, M. & Roufechaei, K.M. 2016. Leadership behavior of project managers in sustainable construction projects. *Procedia – Procedia Computer Science*, vol. 100, pp. 724-730. https://doi.org/10.1016/j.procs.2016.09.217

Taber, K.S. 2018. The use of Cronbach's *alpha* when developing and reporting research instruments in science education. *Research in Science Education*, 48(6), pp. 1273-1296. https://doi.org/10.1007/s11165-016-9602-2

Toriola-Coker, L.O., Alaka, H., Bello, W.A., Ajayi, S., Adeniyi, A. & Olopade, S.O. 2021. Sustainability barriers in Nigeria construction practice. *IOP Conference Series: Materials Science and Engineering*, 1036(1), article nr 12023, pp. 1-12. https://doi.org/10.1088/1757-899x/1036/1/012023

Vazquez, E., Rola, S., Martins, D., Freitas, M. & Rosa, L.P. 2011. Sustainability in civil construction applied in the construction site phase. *WIT Transactions on Ecology and the Environment*, vol. 144, pp. 265-276. https://doi.org/10.2495/ECO110241

Veselovská, L. 2017. Factors influencing countries on their path to sustainable development: Implications for organizations. *Problems and Perspectives in Management*, 15(2), pp. 474-485. https://doi.org/10.21511/ppm.15(si).2017.01

Waidyasekara, K. & Fernando, W.N. 2012. Benefits of adopting green concept for construction of buildings in Sri Lanka. In: Proceedings of the International Conference on Sustainable Built Environment (ICSBE-2012), 14-16 December, Kandy, Sri Lanka, pp. 1-13.

Windapo, A.O. 2014. Examination of green building drivers in the South African construction industry: Economics versus ecology. *Sustainability*, 6(9), pp. 6088-6106. https://doi.org/10.3390/su6096088

Xia, B., Zuo, J., Wu, P. & Ke, Y. 2015. Sustainable construction trends in journal papers. In: Shen, L. & Ye, K. (Eds). *Proceedings of the 19th International Symposium on Advancement of Construction Management and Real Estate*. Heidelberg, Berlin: Springer, pp. 169-179. https://doi.org/10.1007/978-3-662-46994-1_15