ENGINEERING FOR SUSTAINABLE DEVELOPMENT AND LIVING

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Preserving a Future for the Next Generation to Cherish

Edited by

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Dedication

To every person who endeavors towards sustainable living and development.

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Preface

Mike Huckabee put it perspicaciously, "The most important thing about global warming is this. Whether humans are responsible for the bulk of climate change is going to be left to the scientists, but it's all of our responsibility to leave this planet in better shape for future generations than we found it." All of us have the responsibility to exercise good stewardship in realizing more sustainable living and development. This volume brings together experts around the world to disseminate the latest knowledge and research in selected aspects toward engineering for more sustainable development and living. Who could argue against the assertion that collaboration is needed to materialize the sustainability loop? **Abdallah and Estévez** enlighten us that sustainability is part of our DNA in *Chapter 1*; "Sustainable Development and Living—Now or Never." Yes, even a living cell utilizes inherited biological intelligence to organize its resources for current needs and future existence. For the human species, this includes taking care of every fellow being around the globe. To do so, we must help developing and remote communities to have access to electricity, as exhorted by **Reader** in *Chapter 2*; "Developing Remote Communities: Access to Electricity." Reader highlights that two key targets of UN Sustainable Development Goal 7 are to ensure universal access to electricity and increase the share of renewable energies by 2030. **Zhang, Enevoldsen and Xydis** show that hybrid renewable energy systems can be much more cost effective than on-grid connection for some remote communities in *Chapter 3*; "Hybrid Renewable Energy Systems—An Emerging Way for Power Generation only for Off-grid Cases or not?" One cannot avoid energy storage when discussing renewable energy. In *Chapter 4*, "Beyond Efficiency: Balanced

Renewable Energy Storage System for the Future," **Onwuchekwa** posits the right question concerning how we can manage the 'toilet paper crisis' when fossil fuel utilization is suddenly halted. While Mars may be a future possibility, the more down-to-earth solution is to be ready to deploy efficacious energy storage systems to fill the void with renewable energy more promptly. To further energy efficiency in building, the local weather needs to be more accurately accounted for. **Sharma** presents "Joint Frequency Bin Weather Data a More Accurate Approach in Estimating Air-conditioning Load," in *Chapter 5*. It is shown that joint frequency bin data of dry bulb temperature and relative humidity predict building energy requirements more accurately. Talking about energy usage for human thermal comfort, **Balo and Polat** disclose "Energy Productivity with the Effective Design: Case of Medical Waste Storage," in *Chapter 6*. With cooling making up the highest energy cost in medical structures, combining low-energy building strategies with source-efficient and low-cost manufacturing envelopes can carry a long way in mitigating climate change. To ensure improvement, we must assess the performance after implementation of the promising measures. **Gökgöz and Erkul** communicate the energy efficiency scores of European countries in *Chapter 7*, "Analyzing the Sustainable Energy Efficiencies of European Countries." It is shown that some European countries may not achieve the desired levels of sustainable clean energy efficiency. Construction is the right place to start incorporating sustainable development and living. **Jimoh, Yusuf and Oyewobi** present a framework for this purpose in *Chapter 8*, "Framework for Sustainable Construction Practices in Abuja-Nigeria." Another means to promote sustainability is to improve engineering system performance. In *Chapter 9*, "Engineering Vortical Flow via a Cylindrical Rod," **Ahmed et al.** suggest that a cylindrical rod can be exploited to do just that. For example, desirable vortical flows can be generated for enhancing heat transfer and thus the efficiency of many systems which involve heat exchangers. The volume ends with a very timely sustainable living issue, "Post Covid-19: A Water-Energy-Food Nexus Perspective for South Africa," as *Chapter 10*. **Naidoo et al.** provide adaptation strategies through water-energy-food nexus planning, building resilient communities for tomorrow.

Acknowledgments

This book would have been decimated by COVID-19 if not because of providence from above and the resilient experts who furnished the state-of-the-art chapters. A big round of applause goes to the anonymous reviewers who enhanced the quality of each chapter. We are most grateful to William (Xi) Wang who graciously put the individual chapters into one unifying volume. It would be amiss if we do not promulgate the super-supportive team led by Dr. Jeff Young at BrownWalker Press/ Universal Publishers, Inc. We look forward to the opportunity to collaborate for a follow-up on Sustainable Development and Living.

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Framework for Sustainable Construction Practices in Abuja-Nigeria

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ABSTRACT: The construction industry has great negative impact on the environment and as such, the consideration of sustainable development through sustainable construction is needed. Adapting sustainable construction practices is a way for the building industry to move towards achieving sustainability in Nigeria, taking into account the environmental, socio-economic and cultural issues. The aim of the study is to develop a framework for sustainable construction practices in the Federal Capital Territory Abuja, Nigeria. The study adopted questionnaire survey design. A total of 313 structured questionnaires were administered to professionals in the Federal Capital Territory Abuja. The results obtained culminated in the development of framework for sustainable construction practices that highlighted the various roles to be played by stakeholders which if implemented will go a long way to improve

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construction sustainability in Abuja. Efforts should be made by stakeholders especially the governments (Federal, State and Local) and professional bodies to facilitate the provision of a sustainable building code solely for practices, techniques and method of sustainability.

KEYWORDS: Sustainability; sustainable construction; sustainable practices; sustainable development; construction industry; framework; Nigeria

1. Introduction

It is said that the construction industry provides necessary living conditions for the survival and growth of human life on earth (Bal, 2014). The Nigerian construction sector has considerably huge impact on the environment and it is therefore the largest exploitation of natural resources with transformation that are irreversible (Edeoja & Edeoja, 2015). The industry is the largest natural environment destroyer, a major user of non-renewable energy, a major waste generator, an air and water polluter, and a contributor to land degradation (Nwokoro & Onukwube, 2011). The industry is one of the most competitive, dangerous and difficult sectors of the economy; it includes a great deal of waste and issues caused by myopic control. It must change from being reactive to being more constructive if the construction industry has to stem the tide and promote sustainable practices (Bal, et al., 2013).

Dania (2016) stated that building construction is responsible for some of human beings' most wasteful activities with different negative impacts, like wasteful patterns of water and energy use, enormous usage of materials and resources, production of vast amounts of waste, whilst also altering the natural environment and often destroying it. Ian (2019) asserted that new construction materials and techniques can have unexpected impacts on health and safety. Therefore, the industry is confronted with the challenges of building and infrastructure design and construction that cannot withstand more stress from a changing climate.

Sustainability is not seen as a new concept as it has been used since the 1970s (Al Saleh & Taleb, 2010), although the practice still mainly maintains

a conservationist philosophy during the period. Since the Brundtland Report entitled 'Our Common Future' was presented at the United Nations Conference on Environment and Development in 1987, the idea had only gained global political recognition (Lowe & Zhou, 2013). However, most of the published works on the topic of sustainable construction have undeniably been inspired by the initial concept of sustainability, which focuses on the limitation of resources and the reduction of their effect on the natural environment, with emphasis on technical issues such as materials, building components, construction technology and design principles related to energy (El Razaz, 2010; Abidin, 2010).

Research has shown that the construction industry plays a major role in achieving sustainable development. The construction industry is slow in its adaptation to sustainable practices in construction projects, despite its perceived position (Aigbavboa, et al., 2017). Global economic activity is projected to have increased fivefold by 2056, global population by over 50%, energy consumption almost threefold and manufacturing activity at least threefold by 2056. In turn, these will significantly increase building construction to curb the rapidly growing world population, which will also increase the use of energy and finite fossil fuel resources, leading to their exhaustion and heavy environmental impacts, depletion of the ozone layer, emissions of carbon dioxide, global warming and climate change (Peter, et al., 2012). It has been identified that the largest single contributors to carbon dioxide emissions that are intimately linked to global warming are residential and commercial buildings. Against this background, it is necessary to have designers, builders, developers and product manufacturers at the heart of the construction industry who are now committed to working together to change the traditional way of construction and move towards a more sustainable one (Yudelson, 2007). Owolana and Booth (2016) emphasised that a number of stakeholders in the construction industry in Nigeria preferred to disregard the more relevant aspects of environmental issues and quality and concentrate more on the economic angle. As such, progress in the adoption of sustainable building practices is still slow in Nigeria, though it is one of the largest economies in Africa. Abidin (2010) stressed that construction practitioners have agreed with the principles of sustainability, many have not yet grasped their significance, and even fewer have turned sustainability into action. Sustainability is still seen as a

"nice-to-have" addition to normal practice and not as the primary motivator driving all decisions in business and growth.

There is still very limited research that includes developing the framework for sustainable building practices while also looking at the roles played by stakeholders (Martens & Carvalho, 2014). Oladokun and Ujene (2018) stated that there is a low level of stakeholder preparedness in Nigeria to adopt sustainable construction. Even so, progress against an appropriate research and development agenda needs to be made so that construction businesses can engage in sustainable practices that are consistent and accessible to a diverse set of stakeholders who are still not positively involved in reporting processes and results (Bal, 2014). In terms of delivering sustainability, the idea of stakeholder engagement, including its practical implementation, is still relatively unexplored. Dania (2016) noted that the Nigerian market does not adequately support the implementation of sustainability. Developing a framework for sustainable practices is a necessity for building professionals, as education of stakeholders can assist in facilitating the development and adaptation of sustainable buildings in Abuja-Nigeria.

2. Literature review

2.1 Sustainability in the construction industry

In the global economy, construction is a huge industry. In 2015, the global construction industry hit US$ 9.5 trillion, accounting for more than 10 percent of its gross domestic product (GDP), accounting for 21 percent of industrial construction within the construction market (IHS Global Perspective, 2016). Sustainability studies have primarily concentrated on two fields, namely construction and infrastructure. In the transition to a more sustainable economy, the construction industry is at the very heart of the challenge we face (Alex & Chris, 2013). Therefore, the sector must change its practices and implement one that includes the recycling and re-use of products to minimize the use of energy and natural resources.

Building organizations need to have a mutual vision, plan and path structure for the shared goal of a prosperous future. It is important to state that the sector must have both the ability and the knowledge to move towards sustainability effectively. Sev (2009) added that there are

several environmental, social and economic impacts on both the existing built environment and the process of adding it to it. As a result, the construction industry has a major social duty to minimise the harm it projects to the environment.

The understanding of sustainability is adapted to an existing meaning in the Brundtland Report (1987), which notes that sustainability is seen as meeting the needs of the present without sacrificing the capacity of future generations to fulfil their own needs (Oladokun & Ujene, 2018). In recent times, the construction sector has been under serious pressure to implement environmentally friendly approaches to gain competitive advantage (Baloi, 2015). Sustainability in construction industry has become the mainstream of the 21st century after the world summit on Environment in 1987 (Abolore, 2012). Murray and Cotgrave (2007) indicated that the meaning of sustainability and sustainable construction is constantly evolving over time and that terms can usually be exchanged to describe a broad approach that addresses humanity's social, economic and environmental challenges.

The construction industry, which is important to improve the quality of life in terms of housing, workspace, services and transport infrastructure, is of high economic significance and has significant environmental and social implications. Studies have shown that the implementation of sustainable construction approaches can benefit construction organisations (Du Plessis, 2007). Therefore, sustainability in the construction industry is germane even in the traditional project delivery method, due to the growing need to save costs, optimize performance and meet the external needs of stakeholders (Oladokun & Ujene, 2018). Alex and Chris (2013) indicated that there will be many opportunities for organizations prepared to take on environmental issues by adopting sustainable construction practices.

2.2 Sustainable construction practices

Organizations should try to integrate and strike a balance between these three dimensions, environmental, economic and social sustainability, and their overall strategies, in order to fully implement sustainable construction practices (Bansal, 2015; Manoliadis, et al., 2006). Adopting sustainable building practices would ensure that, through the more effective use of

resources, the negative impacts of construction on the environment and its inhabitants are minimized (Jorgensen, et al., 2014). These practices include:

Optimize site potential. This principle covers aspects such as proper selection of sites, consideration of any existing buildings or infrastructure, orientation of passive and active solar features of streets and homes, location of access roads, parks, and any high priority resources that should be preserved, such as trees, waterways, snags, and animal habitats (Jorgensen, et al., 2014).

Minimize energy use and use renewable energy strategies. This term encompasses issues such as the importance of substantially reducing the total energy loads by insulation, efficient equipment and lighting, and proper detailing of the envelope as a whole. It also includes reducing the amount of fossil fuels required, implementing, wherever possible, renewable energy systems such as photovoltaic, geothermal heat pumps and solar water heating, and green power to reduce greenhouse gas generation (Rouse, 2010).

Water conservation and protection. This principle covers aspects such as site runoff reduction, control and treatment. Design and construction of areas used inside and outside to preserve water and reduce leaks by ensuring adequate inspections during construction (Jorgensen, et al., 2014).

Use of environmentally preferable products. This principle covers aspects such as defining products that are retrieved, manufactured with recycled content, conserving natural resources, reducing overall material use, sustainability with low maintenance, saving energy and/or water, and reducing operating pollution or waste (Jorgensen, et al., 2014).

Improve environmental indoors quality. This term encompasses techniques to have outstanding acoustical, thermal and visual qualities that have a major impact on wellness, comfort and productivity. Maximized daylight, suitable ventilation and moisture management and the use of minimal or no Volatile Organic Compound (VOC) products are other qualities to be considered (Arijit, et al., 2012).

Optimize processes and maintenance activities. This concept includes products and structures that need fewer water, energy and hazardous chemicals to simplify and decrease operating requirements. They are not difficult to maintain and cost-effective to manage (Jorgensen, et al., 2014).

2.3 Frameworks for the attainment of sustainable construction practices

The essence of framework is to suggest how sustainable construction practices can be achieved. Environmental Impact Assessment (EIA) should be carried out during the planning and design stages of projects, provided that the traditional EIA is expanded to include assessment of all four indicators of sustainable construction (Aghimien, et al., 2018; Nwokoro & Onukwube, 2011). Du Plessis (2007) described framework as a comprehensive outline of interlinked concepts that have been systematically organized to provide structure and serve as a guide to achieving an objective goal, it can be adapted, revised or improved. It provides comprehensive understanding of the concept or theory of these sustainable construction. Framework for sustainable practices is a collection of information that gives comprehensive understanding of the process of these practices. Studies have shown that lack of awareness is the major obstacle to implementing sustainable construction.

A proposed framework by Gunatilake (2013), for the uptake and implementation of sustainable construction (SC) within a construction project environment consists of four main sections. The first section addresses the contextual considerations in developing SC agendas for construction projects. The second section provides a comprehensive view of the nature and objectives of SC. This provides the basis upon which SC objectives can be set for a particular construction project. The third and fourth sections of the framework address the implementation of SC at project level. The framework however lacks basic strategies to optimize sustainable practices and gave a rather generic solution to the way forward instead a detailed step by step guideline to the implementation of SC. Apart from this, it was developed in the context of developed country and as such, its implementation in a developing country will be difficult as the construction environment is different.

Within the context of developing world, Athapaththu and Karunasena (2018) developed a framework for sustainable construction practices in Sri Lanka. The framework considered the following eight (8) sustainable practices' concepts: sustainable legal framework and enforcement;

sustainable construction standards, guidelines or policies; sustainable designs; sustainable procurement; sustainable technologies, processes and innovations; people and organisational structure; sustainable education and training; and sustainable measurements and reporting. The framework is robust and it seems all encompassing but on a closer look, it shows that it is only about government and organisations (contracting firms) leaving out the place of other important stakeholders such as private clients and professional bodies. In addition to this drawback, the sample size used was small; eight semi-structured interviewed were conducted in five contracting firms.

Aliyu (2016) developed a conceptual framework that will enable Abuja develop into a 21st century functional and resilient city of sustainable communities but failed to identify the different types of sustainable construction practices there is, and also failed put into consideration the level of awareness and extent of usage of these practices within Abuja. The various barriers and drivers to its implementation were also missing alongside the roles and actions to be carried out by the various stakeholders. However, the framework developed for this research work encompasses all of the aforementioned variables that appeared to be missing in Aliyu (2016) despite being of the same area of study, necessary for the implementation of sustainable construction practices in the Federal Capital Territory Abuja.

3. Research methodology

The study is part of a larger study that adopted mixed methods design; however, the survey aspect is reported here. Creswell (2014) stated that collecting, analysing and mixing both the quantitative and qualitative data within a single study usually enables the understanding of research objectives in a more comprehensive way. As familiarity and insights have been drawn from the review of past literature in order to develop the questionnaires which were self-administered to professionals in Abuja-Nigeria. The essence of the review was to develop the constructs used in the questionnaire and also to know the current thinking in the subject area from where the constructs used were derived (Abidin, 2010; Abolore, 2012; Aghimien, et al., 2018; Aigbavboa, Ohiomaha, & Zwane, 2017; Athapaththu, & Karunasena,

2018; Baloi, 2015; du Plessis, 2002, 2007; ElZomor, Fortier & Youssef, 2018; Nwokoro, & Onukwube, 2011; Owolana, & Booth, 2016). For the purpose of the study, the unit of analysis constituted professionals of various construction companies and governmental/ regulatory bodies in Abuja. These bodies included The Nigerian Institute of Building (NIOB), The Nigerian Institute of Architects (NIA), The Nigerian Society of Engineers (NSE) and The Nigerian Institute of Quantity surveyors (NIQS) as shown in Table 8.1. The study adopted probability sampling; it is where the researcher includes cases or participants in the sample because it is believed that they warrant inclusion and every case in the population has an equal opportunity of being selected (Chinelo, 2016; Hamed, 2016). Out of 1685 professionals, 313 were randomly selected and considered to be representative of the professionals based on Krejcie and Morgan (1970) table.

The data were analysed using percentile, mean score and factor analysis using principal component analysis. The essence of the mean score results was to determine the strategies' constructs to be included in the framework developed. The factor analysis carried out on the following constructs, level of awareness, extent of usage, barriers and drivers of sustainable practices was to determine their communality values so that constructs with values less than 0.3 were dropped (Pallant, 2011). According to Cliff and Pennel (1967), communality is the important determinant when stability is the main issue as higher communality does not only entail larger stability but that there is the improvement of the loadings due to the stronger factors. In a related development, Pallant (2011) concluded that communalities give information about how much of the variance in each item is explained. When items with low communality values are removed, the total variance explained is increased.

Table 8.1 Sample size of each component of the population frame.

S/n	Registered professionals	Population	Sample size
1	Architects (NIA)	631	117
2	Builders (NIOB)	441	82
3	Quantity surveyors (NIQS)	92	17
4	Engineers (NSE)	521	97
	Total	**1685**	**313**

4. Results and discussion

4.1 Demographic information of the respondents

Table 8.2 shows result of the analysis of the respondents' demographic information. The analysis shows that only 209 questionnaires were received out of 313 that was administered, making it 64.7% percentage of questionnaires returned. The analysis also showed most of the respondents sampled are

Table 8.2 Demographic information of the respondents.

	Variables	Frequency	Valid percent
Gender	Male	142	67.94%
	Female	67	32.06%
	Total	**209**	**100%**
Organisation	Public	142	67.94%
	Private	67	32.06%
	Total	**209**	**100%**
Profession	Architect	39	18.66%
	Builder	113	54.07%
	Engineer	27	12.92%
	Quantity surveyor	22	10.53%
	Others	8	3.83%
	Total	**209**	**100%**
Years of experience	1–5 years	33	15.79%
	6–10 years	58	27.75%
	11–15 years	69	33.01%
	16–20 years	38	18.18%
	Above 20	11	5.26%
	Total	**209**	**100%**
Professional membership	None	12	5.74%
	MNIA	45	21.53%
	MNIOB	112	53.59%
	MNSE	26	12.44%
	MNIQS	14	6.70%
	Total	**209**	**100%**

67.94% male while 32.06 % are female. In terms of organisational type, 67.94% work with the public while 32.06 % work with the private organisations. In terms of professionals' representation, the result revealed that builders (54.07%) are more, followed by Architects (18.66%), the Engineers (12.92%), then Quantity Surveyors (10.53%), and lastly others (3.83%). A look at the year of work experience of the respondents shows that only 15.79% of them have their year of working experience to fall within the 1 to 5 range, while 27.75% and 33.01% falls between the range of 6 to 10 and 11 to 15 years respectively. Also 18.18% and 5.26% of the population falls between the ranges of 16 to 20 years and above 20 years respectively. However, the average years of working experience of the respondents is calculated as approximately 10.79 years. This implies that they are experienced enough to give a valid response.

In terms of professional membership, MNIOB (53.595) are more, followed by MNIA (21.53%), MNSE (12.44%), MNIQS (6.70%) and lastly none (5.74%). Also, the staff strength shows that 51.67% fell under the range 50–249, followed by 36.84% of them ranges above 250, and lastly 11.48% fell into 1–49. Based on the result on the respondents' background information, it was concluded that the respondents are well equipped professionally and in terms of experience to give reasonable insight on the subject under consideration.

4.2 Factor analysis on the variables on sustainable construction practices

Having carried out descriptive analysis and the results that followed, in other to meet with the final objective of the study which is developing a framework for sustainable construction practices, factor analysis using principal component analysis was adopted. Thus variables on level of awareness, extent of usage, barriers and drivers to sustainable construction practices were used.

First of all, the factorability and suitability of these variable for factors analysis was carried out. The sample size of 209 and number of variables (number of items) ranging from 23 to 29 were adequate and subsequently

Table 8.3 KMO and Bartlett's test.

Variables	Bartlett's test of sphericity			KMO
	Approx. Chi-Square	Df	Sig.	
Level of awareness of sustainable construction	636.624	406	0.0000	**0.564**
Extent of usage sustainable construction	623.348	253	0.0000	**0.725**
Drivers of sustainable construction	315.398	190	0.0000	**0.597**
Barriers to sustainable construction	146.406	55	0.0000	**0.582**

considered satisfactory for factor analysis. This decision was based on the reports of (Pallant, 2011; Tabachnick & Fidell, 2017; Hair, et al., 2010). The values of Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity, are another way of determining the factorability of data for factors analysis. A KMO value between 0.5 and 0.7 is adequate, while lower than 0.5 is considered to be unsuitable for factor analysis, while, a Bartlett's test of sphericity with p-value (or sig.) of less than 0.05 as ideal. Based on these, it shows that the data are suitable for factor analysis as seen in Table 8.3 above.

Based on the factor analysis carried out, the communality values of the variables that were less than 0.3 were dropped as earlier stated in the research methodology section. The variables selected to develop the framework are shown in Table 8.4.

Table 8.4 Variables with communality values greater than 0.3.

Major constructs	Number of variables with communality values greater than 0.3
Level of awareness	8
Extent of usage	8
Barriers to sustainable practices	6
Drivers for sustainable practices	13

4.3 Strategies to optimize sustainable construction practices

Table 8.5 shows the result of the analysis of the strategies to be adopted for optimization of sustainable construction practices in Abuja. The mean values that evolved are as follows; mean value of ≥4.50 corresponds to "very high impact", 3.50–4.49 corresponds to "high impact", 2.50–3.49 corresponds to "moderate impact", 1.50–2.49 corresponds to "low impact" and 1.00–1.49 corresponds to "very low impact". It is obvious from the table that the most highly rated strategies according to the respondents are: regular inspections and monitoring of works, provision of resource management plan, provision of sustainable building code, and provision of water management plan, with the corresponding means of 4.48, 4.22, 4.05 and 4.00 respectively. Based on this, seven (7) variables that have high impact to optimize sustainable practices were selected.

4.4 Framework for sustainable construction practices in Abuja

A strategic approach to adding value to an economy in the 21st century entails delivering basic environmental, social and economic services to communities without threatening the viability of the natural, built and social systems upon which they are dependent (Baron & Donarth, 2016).

Table 8.5 Strategies to optimize Sustainable Construction Practices.

Strategies to optimize sustainable practices	Mean statistic	Rank	Decision
Review of Building Code	3.58	7th	High Impact
Provision of Sustainable Building code	4.05	3rd	High Impact
Employ Natural Resource Management Strategy	3.78	5th	High Impact
Provision of Water Management Plan	4.00	4th	High Impact
Enhancement of Indoor Environmental Quality	3.41	8th	Moderate Impact
Provision of Site Management Strategy	3.12	9th	Moderate Impact
Regular Inspections and Monitoring of works	4.48	1st	High Impact
Provision of Sustainable Materials Selection Criteria	3.67	6th	High Impact
Provision of Resource Management Plan	4.22	2nd	High Impact

The ability to build sustainably has become part of the issues that bedevils the construction industry in most developing countries around the world (Al-Saleh & Taleb, 2010). Bold statements as to the poor sustainability of construction projects within the construction industry of developing countries have been made in recent time (Aghimien, et al., 2018).

Figure 8.1 shows the selected variables on level of awareness, extent of usage, barriers and drivers to sustainable construction practices gotten from the factor analysis, these variables are further linked to the highly rated strategies for the optimization of sustainable construction practices. It also shows the various actions and roles to be played by the respective regulatory bodies and parties involved to give better project delivery in terms of quality, time, cost and safety. It is expected that with the increase in the level of awareness by all the stakeholder, the extent of the usage of sustainable practices will improve thereby limiting the barriers inherent in sustainable practices. When appropriate drivers are in place, the right strategies are formulated as shown in the framework and the roles/actions to be taking by professional bodies/regulatory agencies, government and clients are delineated, all these will result in improved built environment, better project delivery in terms of quality, time, cost and safety and sustainable built environment.

According to Tunji-Olayeni, et al. (2018), the challenges to sustainable practices are the lack of awareness among the clients and construction operators and absence of policies and legislation to drive the concept due to the poor support from government in driving it (Aghimien, Aigbavboa & Thwala, 2019). The public as stated by Aigbavboa, Ohiomaha and Zwane (2017) is of the opinion that it is the responsibility of the government and the construction industry to drive sustainable practices. To this end, Goh, Jack and Bajracharya (2020) advocated for institutional strategies and policies, and project delivery frameworks. Lending their voice to the sustainability agenda, ElZomor, Fortier and Youssef (2018) asserted that the construction phase is one of the construction processes that need additional awareness to implementing sustainable practices during construction.

From the foregoing, for sustainable practices to have a foothold in Nigeria, there is the need to go back to the issues raised by Du Plessis (2002), 18 years after, the issues are still very germane. These are:

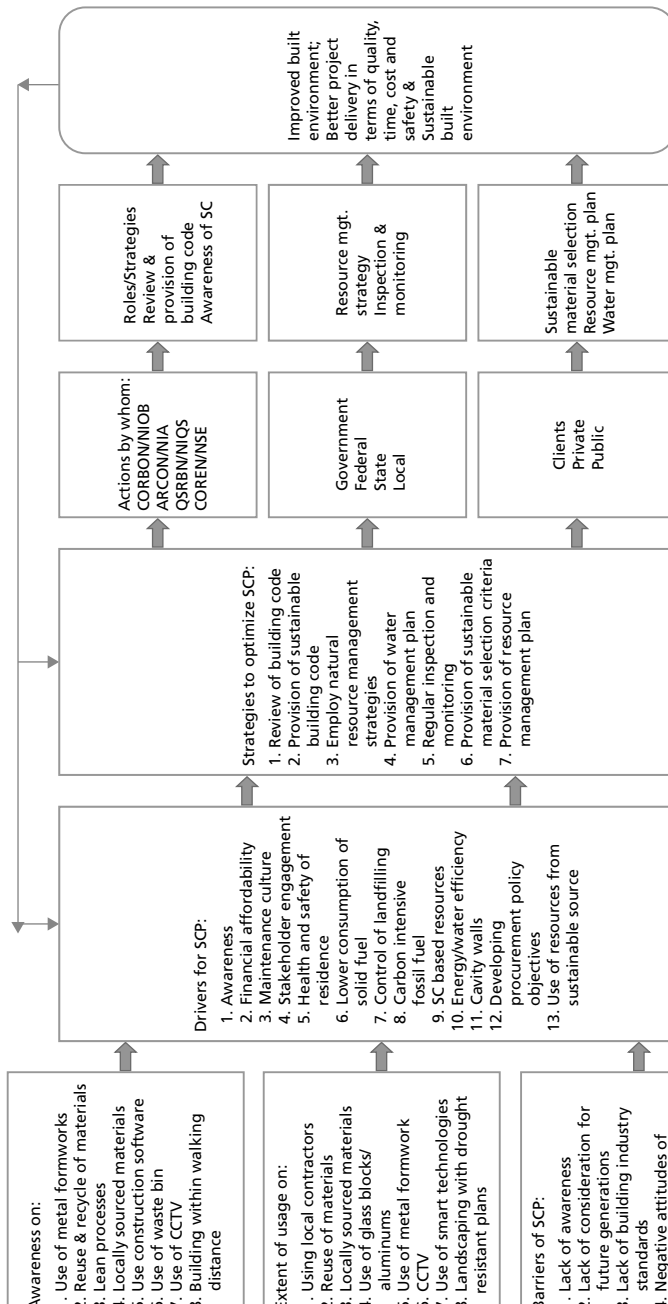

Figure 8.1 Framework for sustainable construction practices in Abuja.

1. There is the need for the revision of curricula and programmes of tertiary educational institutions taking into cognisance sustainability practices while not losing focus on the gap in the education of all stakeholders such as the clients, policy/decision makers and professionals that has to be filled.
2. Public awareness must be raised regarding what the people and the environment stand to gain from sustainable practices.
3. Creation of synergy between researchers and those to implement the outcome of the research efforts.
4. Development of appropriate policies and legislation by reviewing the existing laws. The laws should be such that incentives are provided in order to encourage the practice of sustainability especially by clients and contractors. In doing these, best practices have to be adopted.
5. Enforcement of the laws should be pursued vigorously so that violators can be sanctioned appropriately. It is expected that professional bodies such as the Council of Registered Builders of Nigeria (CORBON), Quantity Surveying Registration Board of Nigeria (QSRBN), Council for the Regulation of Engineering in Nigeria (COREN) and Architects Registration Council of Nigeria (ARCON) will help in sensitising their members on the practice of sustainability.

5. Conclusion

The main thrust of the study was to determine and harness sustainable construction indices which would form a robust framework for construction stakeholders in Abuja, this was achieved as the framework developed, if imbibed will be used to enable collaborative training and integrated practice among the professionals towards the implementation of sustainable construction in Abuja. It can also be used as a criterion to benchmark the gaps in process and strategy for a sustainable construction industry in order to capture good practices, minimise environmental impacts and improve Abuja and by extension Nigeria's readiness towards sustainable construction. Based on these, there is the need for proper sensitization of the public on sustainable construction practices on its importance and necessity to human and the environment. Furthermore,

efforts should be made by stakeholders especially the governments (Federal, State and Local) and professional bodies to facilitate the provision of a sustainable building code solely for practices, techniques and method of sustainability.

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