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Managing The Barriers to Sustainable Construction Technologies in Ghana: A Conceptual Stakeholder Approach

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Abstract
Over the past two decades, the subject of sustainable construction technologies and sustainable development goals have been a driving global agenda. Nonetheless, the Ghanaian community continues to experience challenges in fully integrating sustainability into the construction biosphere to harness the associated gains. The objective of this research was to conduct a current study on the barriers to sustainable construction in Ghana and propose a conceptual model for managing these barriers. As a quantitative studies, questionnaires were purposively distributed to professionals in the built environment who were conversant with the subject of sustainability. Using relative importance indices, analysis of the responses from respondents indicates that the seven most effectual factors impeding the assimilation of sustainable construction technologies in Ghana are lack of strategic approach, lack of demand, lack of governmental support, high construction cost, lack of awareness and lack of technical expertise. To manage these barriers, an integrated stakeholder approach towards the adoption of sustainable construction was proposed that commences with a policy drive aimed at aimed at propelling a mindset change, value change and social change that would produce a cooperate acceptance. Wholistically, all key stakeholders including the statutory bodies, educational institutions, professional bodies, social actors, media houses, civic groups, chiefs and opinion leaders would be required to be partners to the above strategic drive to enhance an effective community penetration. Through public education, whilst the gains from sustainable construction technologies are highlighted, the dangers of construction pollution and environmental degradation would be recounted.
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1.0 Introduction

Buildings, infrastructure and the creation of settlements are part of our environment that affect our health, living conditions, social well-being, human dignity and hence economic equity (Osuizugbo, Oyeyipo, Lahanmi, Morakinyo & Olaniyi, 2020a). In line with the sustainable development goal (SDG) 11 which focuses on the development of sustainable cities and communities concurrent with SDG 3 which focuses on good health and well-being, SDG 6 on clean water and sanitation, SDG 9 on industry and innovation and infrastructure, SDG 13 on climate change and SDG 15 on life on land, there has been the emergent need to create a safer environment through sustainable design and construction around the world. According to (Zainul, 2010) sustainable construction is postulated as the creation of a responsible management of a healthy built environment (Raymond J. Cole, 2005; Häkkinen & Belloni, 2011) based on the prudent use of resources and ecological principles to achieve social and environmental benefits whilst minimising impact (Redclift, 2005). Within the built environment domain, sustainable construction involves the design, construction and occupation of buildings using resource-efficient methods and materials that do not compromise the health of the environment or the associated well-being of the construction worker, building occupants, the general public, or future generations (Yin, Laing, Leon & Mabon, 2018). The International Council for Research and Innovation in Building and Construction (CIB) (Bourdeau, Huovila & Lanting, 1998) therefore postulates sustainable construction as 'the sustainable production, use, maintenance, demolition, and reuse of buildings and constructions or their components. Invariably, sustainable buildings and built environments are seen as 'the contributions by buildings and the built environment to achieving components of sustainable development' (Sjostrom & Bakens, 1999).

According to the World Commission on Environment and Development (Redclift, 2005), sustainable development is a holistic process aiming to restore and maintain harmony between natural and built construction while creating settlements that affirm human dignity and encourage economic equity (Tafazzoli, 2018). Sustainable Construction can therefore be described as the subdivision of sustainable development and its application to the construction industry (Dosumu & Aigbavboa, 2021). The construction industry, which includes all stakeholders who plan, develop, procure, produce, design, modify or maintain the built environment products as well as manufacturers and suppliers of construction materials, clients, contractors, consultants and end users of these facilities (Buertey et al., 2016) are expected to be key stakeholders (Buertey et al., 2021) of sustainable development (Ametepey, Gyadu-Asiedu & Assah-Kissiedu, 2015a). As a global standard, sustainable construction addresses the needs of both the present generations whilst planning for the future in terms of environmental resource heritage (Redclift, 2005). To attain the goal of sustainable development, sustainable designs are key, aimed at creating buildings that are energy efficient, healthy, comfortable, and flexible in use considering life cycle factors.

The Organization for Economic Co-operation and Development (OECD) postulates that the building sector has major impacts not only on the economic and social life of people but also on the natural and built environment (Wallbaum & Buerkin, 2003). Various building activities, such as the design, construction, use refurbishment and demolition of buildings, directly and indirectly, affect the environmental performance of the sector" (Esezobor, 2016). The concept of sustainability is therefore not just about reducing the negative impact of construction on the environment, but by introducing the idea of restoring the environment, as well as highlighting the socio-economic aspects of sustainability (Osuizugbo et al., 2020a). According to (Kibert, 2003, 2016a) three aspects of sustainable construction are worth evaluating:

1. It requires a broad interpretation of construction as a cradle-to-grave process, involving many more role players than those traditionally identified as making up the construction industry.
2. It emphasizes both environmental protection and value addition to the quality of life of individuals and communities.
3. It embraces not just technological responses, but also the non-technical aspects related to social and economic sustainability.

Against this background, the concept of "sustainable building" which includes reducing the harmful effect of building and construction activities on the environment has attracted the attention of stakeholders in OECD countries (OECD. Environment directorate., 2003). This can range from efficient construction waste disposal, using recycled construction materials (Buertey, Offei, Adjei Kumi & Atsrim, 2018) low-polluting forms of transport in construction and maximizing energy efficiency in finished building through improved insulation and renewable energy (OECD. Environment directorate., 2003). To this end, it can be projected that sustainable construction requires less use of natural resources and increases the reusability of such materials and products for the same or similar purpose, thereby reducing waste (Akinshipe, Oluleye & Aigbavboa, 2019).

Concerning pollution, cement production alone contributes greatly to the emission of CO_2 into the environment. Cement emits approximately 8% of global carbon dioxide (Alghamdi, Shoukry, Abadel & Khawaji, 2023) and other pollutants like sulphur dioxide, nitrogen oxides, and particulate matter (Zhu, Jinzhong Yang, Qifei Huang & Tao Liu, 2022). These contaminants can harm humans and the environment. For every ton of cement produced, approximately a corresponding ton of carbon dioxide is released into the atmosphere. Moreover, concrete production contributes twice the total CO_2 of all building materials put together (Dhandapani, Sakthivel, Santhanam, Gettu & Pillai, 2018; Alghamdi et al., 2023; Bhavani & Prasad, 2023). Steel remains one of the most energy-intensive materials and for that reason contributes immensely to climate change (Danquah, 2021). The usage of these materials leads to the destruction of the environment, through pollution (both in extracting raw materials and construction of buildings), dust and hazardous contamination through toxic waste (Sjostrom & Bakens, 1999). It is estimated that half of all waste materials by weight are due to building activities (Aytekin & Mardani-Aghabaglou, 2022), including soil movements which also generate immense pollution during transportation and usage (Bourdeau et al., 1998). The construction sector is therefore a substantial source of waste, a polluter of air and water, a major consumer of non-renewable resources, and an important contributor to land waste (Wallbaum & Buerkin, 2003; Cheer-Germ, Jun-Ren, Jen-Hao, Cheng-Tung & Yue-Lin, 2012). Nonetheless, it is possible these shortfalls could be reduced if not eliminated through sustainable designs and construction processes.

The goal of achieving sustainability takes into account the ecological and social performance as well as the financial performance of the project. One of the major motivational factors behind sustainable buildings is to mediate the construction industry's negative impact on the natural environment including ozone layer depletion, global warming, acidification potential, solid waste, ecosystem destruction, air and water pollution and natural resource depletion (Ahn, Pearce, Wang & Wang, 2013a; Kibert, 2016a; Ifije & Aigbavboa, 2020).

2.0 Literature review

2.1 Principles and Drivers of Sustainable Construction

Abimbola (2013) has postulated that sustainable construction may be categorized along economic or ecological dimensions. Thus, whereas economic factors focused on Stakeholder demand (Buertey et al., 2016) (government, developers, green building councils, building materials manufacturers and tenants to reduce building operating costs and acquire a competitive advantage; financial benefits of green building as a result of various incentives and reduced operating costs), ecological/societal factors focus on reduced environmental impact/need for environmental sustainability and the need for corporate social responsibility (Tzschentke, Kirk & Lynch, 2004; Tomkiewicz, 2011). Pennell et al., (2013) identified six key values related to sustainability as the minimisation of resource consumption, maximisation of resource reuse, use of renewable and recyclable resources, protect the natural environment, create a healthy and non-toxic environment; and pursuit of quality in creating the built environment. Again, (Ametepey, Gyadu-Asiedu & Assah-Kissiedu, 2015b) asserted that a sustainable construction industry does not simply mean continuing its business and growth along traditional lines but the need to incorporate sustainable design reviews and principles in all its endeavours.

According to a survey conducted in Thailand in 2014, the top five factors that contributed relatively highly to the implementation of sustainable construction in building projects are greater availability of green products, superior building performance, increasing client awareness about sustainable construction, and willingness and demand of client (Ahn, Pearce, Wang & Wang, 2013b). Other key factors are the enforcement of legislation (building regulations) and Planning policies of the government and local authorities that include sustainable construction as part of planning criteria when awarding planning clearance and building permission (Lima, Trindade, Alencar, Alencar & Silva, 2021; Luo, Sandanayake, Hou, Tan & Zhang, 2022).

Through the introduction of sustainable principles into the briefing and design process, three main benefits are reaped: environmental, economic and community health benefits (Huovila, 1998). Thus, whereas environmental benefits aim at improving air and water quality, reduction of waste disposal, and water and energy consumption; the economic benefits, on the other hand, aim at reducing lifecycle costs (Tunmise & Abimbola, 2015). The health and community benefits on the other may include enhancing sustainable design and construction through the use of lower energy, reducing harmful emissions, and enhancing reusable, renewable, recyclable, and reparable resources (Huovila, 1998). In light of the impact of construction on the environment, society and the economy, the construction industry has been identified as a key driver towards the achievement of sustainable development (Bond & Perrett, 2012). Nonetheless, Opoku & Fortune (2011) suggest that the construction industry in countries like Ghana is however very slow in adopting sustainable approaches to its construction project practices. Sustainable development, however, is governed by three broad components; social, environmental, and economic; often known as the 'triple bottom line', as shown in Figure 1 (Shelbourn, et al., 2006).

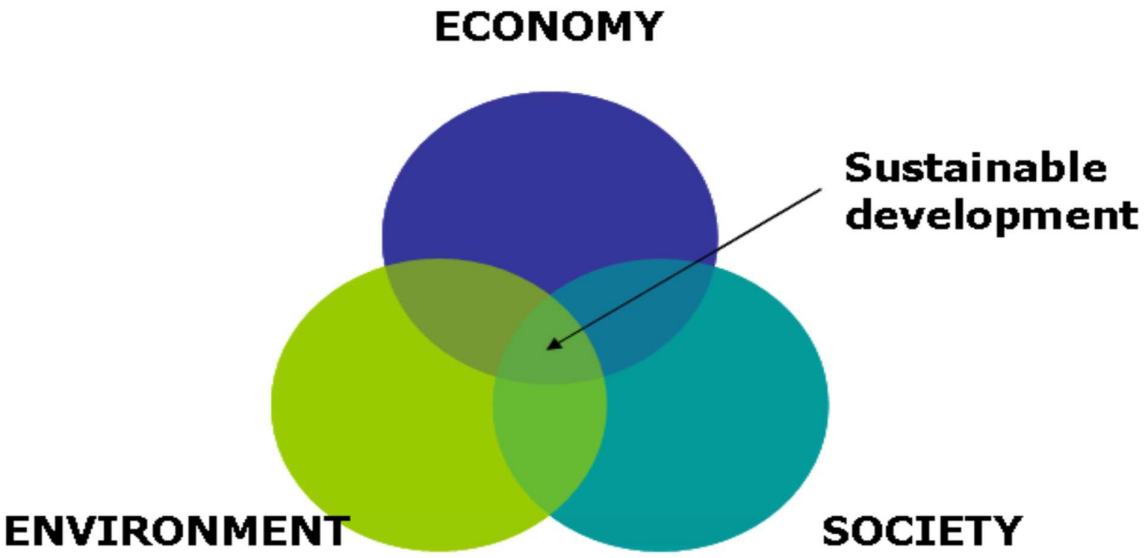

Figure 2.1 The triple bottom line

2.2 Balancing Sustainability and Economy

Globally, the construction industry constitutes more than half of the national capital of most countries and represents as much as 10% of GNP (Ive & Gruneberg, 2000; Buertey & Adjei-Kumi, 2012). This sector accounts for around one-tenth of the world's GDP and creates at least 7% of its jobs (Udomsap & Hallinger, 2020). Ahadzie et al., (2009) acknowledge that construction contributes to national socioeconomic development by providing significant employment opportunities. Beyond that, the industry provides the infrastructure and facilities required for other sectors of the economy to flourish such as schools for education and training, factories and shops for commercial and business activities, housing for basic human needs, hospitals for health care, and buildings for the national communications network (Carlander & Thollander, 2023). Historically, the level of construction projects has been related to the level of a country's developmental progress (Arogundade, Dulaimi & Ajayi, 2024). It can be observed that declining economies have always been identified by declining construction activities and vice versa (Yin et al., 2018). Although the importance of the construction industry cannot be overemphasised, its effect on society and most especially the environment is always not positive and hence require a critical review.

Estimatedly, buildings are responsible for almost half of the carbon emissions, half of the water consumption, about one-third of the landfill waste and one-quarter of all raw materials used in almost every economy (Oke, 2021). Since sustainable construction must be seen as development which meets the economic needs of the present generation without compromising the ability of future generations to meet their own needs, construction activities must be planned to be environmentally, socially, and ecologically responsible (Araújo, Carneiro & Palha, 2020). Sustainable construction projects therefore play an important role in ensuring economic growth without negatively affecting society and protecting future generations (Adetunji, Price, Fleming & Kemp, 2003). Due to the vital role construction plays in every economy, it is important that such projects are effectively planned and managed through the application of effective project management tools and techniques (Buertey, Doe, Atsrim & Sarfo, 2023) to ensure successful delivery (Shurrab, Hussain & Khan, 2019).

Since sustainability is about planning for the fourth generation, there is therefore a need to find a balance between economic, environmental, and social factors in the design, construction and use of buildings, hence the birth of the sustainable construction industry. The main aim of sustainable construction is therefore to reduce the impact of building on the environment and society and make available resources for future generations to come (Perera, Opoku & Rodrigo, 2022a). While standard building practices are guided by short-term economic considerations, sustainable construction is based on best practices which emphasize long-term affordability, quality and efficiency (Shelbourn et al., 2006).

2.3 Sustainability and Ecology

Whilst construction has a significant effect on the quality of life, its output alters the nature, function and appearance of the ecosystem in which people live and work. Statistically, built environment activities worldwide consume up to 40 per cent of the total energy (Ghosh, 2020), 40 per cent of the raw materials consumed, and 60 per cent of the world's electricity each year (Malhotra, Behal, Choudhary & Kaushik, 2021) with half of the world's fossil fuel consumption is used to serve buildings (Mavi, Gengatharen, Mavi, Hughes, Campbell & Yates, 2021). In addition, the built environment uses over 420 million tons of resources for construction, 6,500 hectares of land are converted from rural to urban, and 90 million tons of construction and demolition waste is generated (Ametepey et al., 2015a). The industry has therefore been accused of causing environmental problems ranging from pollution to excessive consumption of global resources (Mavi et al., 2021). Sustainable construction is therefore critical for the responsible management of a healthy built environment based on the prudent use of resources and ecological principles (Kibert, 2016a).

The ethos of sustainable construction requires a cradle-to-grave appraisal of every project, which involves managing the serviceability of the project lifecycle issues and eventually reconstruction focused on the economic aspect of sustainability. A building designed and constructed sustainably minimises the use of natural resources, raw materials, energy, land, etc over the whole life cycle of the building, whilst incorporating the basic themes of sustainable development (Persson & Grönkvist, 2015). Such construction processes would thus bring to the fore environmental responsibility, social awareness, and economic profitability objectives for the wider community benefit (Kibert, 2016b). The basic strategy for sustainable construction suggests key factors for action by the construction industry by widening the basic tenets which include preserving and enhancing biodiversity, monitoring and reporting and benchmarking performance (Council, 1996).

Finally, the building cycle from materials manufactured to onsite works produces large quantities of waste, both hazardous and non-hazardous materials which must be managed efficiently. In the homebuilding industry, the primary sources of hazardous wastes are generated from painting, sealing, staining and caulking. Using products that minimize the inclusion of hazardous elements is recommended, and appropriate disposal methods should be observed (Tomkiewicz, 2011).

3.0 Barriers to Sustianble Construction

Despite the advantages of sustainable construction, there are many barriers to its implementation. Some barriers identified in literature can be grouped into four primary categories namely (Ifije & Aigbavboa, 2020): socio-cultural, financial, steering and professional barriers (Takyi, Amponsah, Duamor, Azunre & Ahadzie, 2002). Other studies by (Ametepey et al., 2015a) also identified political and knowledge/awareness challenges as some barriers to sustainable construction. Below are some of the discussions of the barriers to sustainability in Ghana.

3.1 Socio-cultural barriers

The socio-cultural barriers include the lack of demand and public awareness and the cultural resistance to change. Construction in Ghana over the years favours the use of blocks and reinforced concrete and discourages any other alternative to these building materials and services. This poses a major barrier to change. to date almost 70% of Ghanaina construction are in masonry and concrete with less than 1% in brick and timber (Statistical Service of Ghana, 2021; Kuffo, Ewusie Jnr., Newton-Akpor, Ahiadu, Kesse & Appiah, 2023). Over the years every attempt to introduce the citizeny to light weight and sustianble contsruction technologies are resisted (Danquah, 2021).

The construction industry processes over the past century present itself as a sector which is traditionally very difficult to change, especially with respect to construction methods practiced and the use building materials (Djokoto et al., 2013). Due to the complex and fragmented nature of the construction industry, it has the tendency to resist changes leading towards sustainability. Some local construction organizations have the perception that sustianble construction technologies it will result in increased risks, higher capital costs, and even difficulties in obtaining financial support due to the lack of market awarness (Opoku & Fortune, 2013). Again, the industry which is client-driven plays a major role in the adoption of sustainable construction practices (Centobelli, Cerchione, Ertz & Oropallo, 2023; Nawaz, Chen & Su, 2023). The challenge is that, there is a lack of client awareness and demand for sustainable building. Since companies follow the consumption patterns of clients who normally worship modernity and the development model of developed countries, the lack of interest is a key challenge.

3.2 Political barriers

Consistently, there is the lack of government drive to initiate policies or legislations and drive support for sustianability. Over the period, there is a lack of promulgation of building codes on sustainability and its enforcement to compel its citizenry to move towards sustainability. There is therefore very little compelling effort in the existing Ghana Building codes to drive the currently ongoing global sustainability agenda in Ghana. Since the government is a key stakeholder in the industry, it has to play a major role such as providing the enabling environment for its effective implementation (Ametepey et al., 2015a). Sustainable Construction would hardly be successful without the commitment of the state and legislation.

3.3 Financial Illitracy and Barriers

There is a common perception that sustainable construction is more expensive in terms of the initial capital costs which they fail to compare to the lifecycle benefit. Even though there are high investment costs for sustainable construction compared with traditional building practices (Häkkinen & Belloni, 2011), however, the longterm benefits far outweigh the initial cost. Comparing the benefits in the use of natural renewable energies and self-managing green systems in Ghana to the high life cycle cost of existing systems, there is the clear challenge of financial illiteracy or misconception. The misconception that sustainable construction will cost more or increase in capital cost and the lack of a visible market value discourages both construction organizations and investors (Opoku A. & Fortune, 2015), is a peception which needs to be addressed.

3.4 Technical barriers

The lack of technical ability**,** chronic skills and labour shortages pose a major challenges to the implementation of sustainable construction. These challenges are considered technical because they have a direct impact on the successful implementation of sustainable construction principles (Ametepey et al., 2015a). Designers in the construction industry seem not to be very confident when sustainable designs are discussed. This suggests that professionals within the built environment need to be fully acquainted with the principles to implement it. Typically, Ghanaian contractors and stakeholders are not keen on taking risk or being innovative. Despite a purported desire to adopt sustainable construction practices, the industry is further hampered by a lack of capacity to actually implement sustainable practices (Djokoto et al., 2013). Some professionals within the built environment are not fully trained in sustainable construction principles and thus lack the know-how to properly execute such practices. In addition to forming an appropriate knowledge basis, these professionals would benefit from training in how to engage with owners/end users, investors, developers, designers, and contractors (Ahmed et al., 2014). The workforce of every industry is its backbone as such the need to involve professionals who are not only knowledgeable but can promote sustainable construction working as a team. This barrier if unattended will indicate a considerable knowledge and skills gap in the construction sector (Perera, Opoku & Rodrigo, 2022b)

3.5 Lack of accurate data

Accurate data and information are critical to achieving effective sustainable construction processes and policies. Information is needed on current "green" building materials that are available, including the types of materials, how they are employed, and the resources consumed over their life cycle. Similarly, it is also important to have accurate information about the number of construction operatives, their mode of operation and the sector in which they operate. In developing countries, the paucity of even baseline population data is well acknowledged, imposing further constraints on effective planning. Although there are government institutions charged with the tasks of gathering statistical information, they often exist only in name. Indeed, much Statistical information for the construction sector is often either unavailable or unreliable. Data and information on the health effects and risk of unsustainable construction activities are also not very reliable and often insufficient. The lack of data about the exact connections makes decisions on interventions difficult (Maqbool & Amaechi, 2022).

3.6 Lack of Local Technological Inertia and Research Planning

Another barrier is the lack of research on the use of local materials for sustainable construction. Existing construction methods are primarily exotic and favour the use of construction materials such as steel, reinforced concrete and bricks and discourage any alternatives to these building materials and types of services. Technological dependency hinders the autonomous development of dependent countries in developing their own technologies.

Developing countries need knowledge and technology that is better adapted to their own natural resources than that which they obtain from industrialised countries. The lack of national technological policies supportive of traditional technologies creates favourable conditions for the reproduction of the technological models adopted in the developed countries, with such models not suited to the reality of the developing world. Research by professional bodies should be encouraged to discover new solutions and adaptation of traditional methods without endangering people's safety and health (Bourdeau, 1999). For example, in Ghana, the Building and Road Research Institute of the Council for Scientific and Industrial Research has done some major research into sustainable construction, however, this has not been disseminated on a large scale for it to be practised. This lack of integrated research planning and dissemination between the theoretical and practical spheres is a further obstacle to sustainable construction.

3.7 Lack of Economies of scale -Uncertain economic environment

In developing countries, the private sector has a very narrow market base and the formal construction industry overly relies on the government for work. In a Country like Ghana where there are a lot of pressing issues like health care, unemployment and agricultural all requiring financial assistance from the government, public spending is often prioritised because of fiscal prudence or simply because the government is bankrupt. Delays with interim and final payments, as well as onerous contract conditions faced by construction firms, can also impose huge constraints on the industry. Many construction firms have suffered financial ruin and bankruptcy because of delays in payment, which are common with government contracts. This is further compounded by the political instability that prevails in developing countries, where new regimes often refuse to honour the contracts issued by their predecessors. One of the reasons for the lack of interest by the private sector in developing sustainable products that are accessible to the various income groups of the population is the lack of alternative financial and micro-credit mechanisms to encourage changes in present practices. Developers/financers and contractors also do not recognise sustainability as a means to competitiveness in local or foreign markets (Kats & Alevantis, 2003).

5.0 Methodology

The research was approached quantitatively with data drawn from four categories of practitioners within the construction industry: Project Managers, Architects, Quantity Surveyors and Civil/Structural Engineers. The study design led to a choice of only practitioners registered with their various professional bodies. From a population of 500 practitioners, a sample size of 171 was determined using (Yamane, 1967) from the equation:

$n = N / (1 + Ne^2)$

Where n is the estimated sample size, N is the total population and E is the level of precision (indicated as 5% and 95% confidence levels were used for the study).

So n= 300 / (1+300*0.05^2) = 171 respondents.

A questionnaire was designed as the instrument for data collection. The instrument was grouped into three sections with section one focussing on the consciousness and knowledge of sustainable construction, barriers to sustainable construction and benefits to sustainable construction technologies in Ghana. In terms of data collection, respondents were selected to answer the research questions purposively due to the nature of the study and the expert nature of the subject. Out of 171 questionnaires personally distributed, 95 were retrieved indicating a response rate of 56%. Data was analysed using univariate statistical analysis through percentages and relative importance indices and displayed using graphs. The relative importance index (RII) was used to rank the respondent's views on barriers to sustainable construction using the formula below:

$$\text{RII} = \frac{n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{5(n_1 + n_2 + n_3 + n_4 + n_5)}$$

Where n_1 = number of respondents who marked 'not important'

n_2 = number of respondents who marked 'less important'

n_3 = number of respondents who marked 'important'

n_4 = number of respondents who marked 'very important'

n_5 = number of respondents who marked 'highly important'

6.0 Data Analysis and Discussion

6.1 Consciousness and Knowledge of Sustainable Construction

Analysis of the first question which related to awareness of sustainable construction revealed that all (100%) of the respondents indicated that they had heard of the concept. However, some twenty per cent (35%) indicated they had not incorporated sustainable construction practices in their designs of construction. The table below indicates how the professional gained knowledge or awareness about sustainable construction.

Table 1: How respondents heard about Sustainable construction

Mode	Frequency	Percentage
Media / Magazines / Newsletters	22	30.6
Workshops	10	13.9
Academic work	40	55.5
Total	72	100

Table 1 shows where and how the respondents heard of the concept. Fifty-five point five per cent (55.5%) indicated they heard of the concept through academic work, while thirty point six per cent (30.6%) was through the media/magazines/newsletters. Only thirteen-point nine per cent (13.9%) heard of the concept through various workshops.

6.2 Analysis of Barriers to Sustainable Construction

From table 2, a list of 16 possible barriers, respondents were required to choose the degree to which the variable affected the implementation of sustainability of construction technologies in Ghana. The possible factors included lack of public awareness, higher financial cost, lack of incentives, lack of demand, lack of technical expertise, lack of government/political support, lack of building codes and regulations, lack of Ghanaian measurement tool, socio-cultural challenge, lack of strategy to promote sustainability, management/leadership challenge, and lack of education. The following analysis was carried out on the ninety-five questionnaires that were returned. As indicated earlier, the barriers identified from a number of literature and buoyed by industry practitioners were ranked according to their relative importance index (RII).

Table 2: Relative Importance Index of Barriers to Sustainable Construction in Ghana

No	**Barriers to sustainable construction.**	**Mean**	**Std. Dev.**	**Sum**	**Relative Importance Index (RII)**	**Rank**
1	Higher financial cost	3.33	1.10	338	0.712	3rd
2	Lack of public awareness of the benefits of sustainability	3.31	1.09	298	0.627	5th
3	Lack of green building codes and regulations	3.17	1.23	285	0.600	8th
4	Lack of demand	4.09	0.88	368	0.774	2nd
5	Lack of financial incentives	2.96	1.25	266	0.561	10th
6	Lack of government/political support	3.40	1.22	306	0.644	4th
7	Resistance to change	3.23	1.20	290	0.611	7th
8	Lack of education	3.00	.99	283	0.595	9th

9	Lack of technical expertise	3.24	1.16	292	0.615	6th
10	Lack of strategy to promote sustainability	3.50	1.25	415	0.873	1st
11	Management/leadership challenge	3.00	1.10	265	0.558	11th
12	Lack of Ghanaian measurement tool	3.36	1.01	247	0.521	12th
13	Socio-cultural challenge	2.98	1.15	242	0.510	15
14	Lack of information on green technologies	3.16	0.96	245	0.515	14
15	Lack of data on existing buildings with sustainable construction technologies	2.84	1.18	239	0.504	16
16	Lack of suppliers and installers with green building and sustainable construction technologies	277	1.13	246	0.518	13

Plotting the RII of the factors in descending order as shown in figure 1, this study showed that the seven most important barriers to sustainable construction in Ghana were lack of strategy to promote sustainability (RII = 0.873), lack of demand (RII = 0.774), higher financial cost (RII= 0.712), lack of government/political support (RII = 0.644), lack of public awareness of benefits of sustianbaility (RII = 0.627), lack of technical expertise (RII = 0.615), resistance to change (RII = 0.611), Lack of green building codes and regulations (RII = 0.611), lack of education (RII = 0.600) and Lack of financial incentives (0.561). These top ten barriers to sustainable construction according to this study are shown in Table 2 below. On the other hand, the three weakest barriers to sustainable construction were lack of data on sustainable construction (RII=0.504), socio cultural challenges (RII =0.510) and lack of information, suppliers and installers on sustainable technologies (RII =0.504).

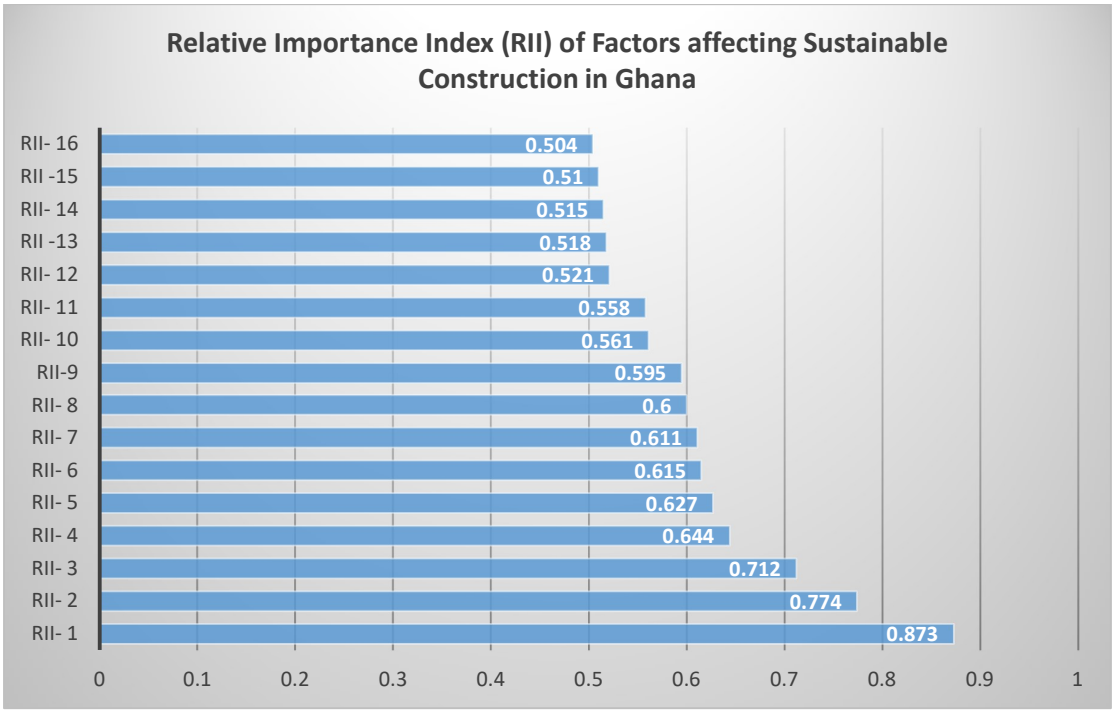

Fig. 2: Relative Importance of Factors affecting Sustainable Construction in Ghana

6.3 Discussions

6.3.1 Lack of local strategy to promote sustainability

With an RII of 0.873, the lack of a local Strategy to Promote Sustainability was ranked as the first barrier to sustainability. The high importance of strategy suggests that there is a critical need for coherent policies and plans to promote sustainable construction practices effectively. This might involve government action, industry collaboration, and community engagement to create and implement effective strategies.

According to the Strategic Management Theory (Haberberg & Rieple, 20208), to initiate key drivers to change within the social construct, there is the need for the formulation and implementation of major goals and initiatives taken by key actors of these institutions to achieve its objectives. These stakeholders in Ghana include the government, professional bodies, statutory organisations, educational institutions and major clients. A well-defined local strategy for sustainability will therefore involves setting clear goals, allocating resources, and implementing policies to drive sustainable construction. Using the institutional theory (Dacin, Goodstein & Scott, 2002), there is the need to emphasise the role of institutions in shaping social behaviours and thought systems. Institutions, including governments and regulatory bodies, play a crucial role in establishing policies, rules, and strategies that promote sustainability. The absence of a local strategy to promote sustainability in Ghana can hinder the adoption of sustainable construction practices. As corroborated by (Osuizugbo, Oyeyipo, Lahanmi, Morakinyo & Olaniyi, 2020b) there is hence the need to set clear goals and Policies and a nation aimed at achieving sustainable development in Ghana. Again, a coherent strategy with a clear direction and strategic resource Allocation is crucial to driving the sustainability agenda in Ghana.

6.3.2 Lack of Demand

With an RII of 0.774, the lack of demand in the area of emerging construction and green technologies was identified as the second barrier to sustainable construction. This could be due to a lack of awareness among potential clients, or the perceived high costs associated with sustainable practices, compatibility issues and policy and incentive gaps. This highlights the need for increased marketing and demonstration of the long-term economic and environmental benefits of sustainable construction. The initial costs of sustainable technologies are often higher than conventional options, deterring demand despite long-term savings and benefits. Again, potential users may not be fully aware of the benefits and performance of sustainable technologies, leading to a slow adoption rate. It is also evident that existing construction practices and infrastructure might not be readily compatible with new sustainable technologies, creating resistance to change.

According to the diffusion of Innovation (Rogers, Singhal & Quinlan, 2014), Everett Rogers explains the how, why, and at what rate new ideas and technology spread. According to this theory, the adoption of innovations, including sustainable technologies, is influenced by factors such as perceived benefits, compatibility with existing values and practices, complexity, trialability, and observability. A lack of demand indicates that these technologies may not yet be perceived as advantageous or compatible by a critical mass of potential adopters. Without sufficient policy support and incentives from the government (as the key stakeholder in this regard), the market fails to create sufficient demand for these technologies. It is recommended that financial incentives such as subsidies, tax breaks, and low-interest loans may be given as incentives to companies involved in sustainable technologies to help offset higher initial costs. Again, awareness campaigns such as educational initiatives and demonstration projects may be used to increase awareness and demonstrate the long-term benefits and performance of sustainable technologies.

6.3.3 Higher Financial Cost and uncertain economic environment

The challenge of Higher Financial Cost was ranked third with an RII of 0.712. This is not surprising since according to economic theories, perceived high upfront costs can deter investment in sustainable practices as corroborated in previous studies by (Chan, Darko, Olanipekun & Ameyaw, 2018). As indicated earlier, the initial investment in sustainable materials and technologies is often higher, despite long-term savings and benefits. This aligns with the principles of capital investment and return on investment (ROI) (Hoff & Stiglitz, 2000). Economic theories on cost-benefit analysis and investment in sustainability argue that while initial costs might be higher (Hoff & Stiglitz, 2000), long-term benefits such as energy savings, reduced maintenance costs, and increased property values outweigh these initial expenditures. The significant RII for higher financial costs highlights the economic challenge of adopting sustainable construction. Stakeholders may be reluctant to invest in sustainable practices due to the perception of higher initial costs, even though these might lead to long-term savings and

benefits. Financial concerns are significant for which a critical intervention may be required by the government through the use of tax waivers and reduced duties on sustainability related issues. To overcome this fear other financial incentives such as grants, subsidies, and tax breaks can help mitigate the impact of higher initial costs. Additionally, demonstrating the long-term economic benefits of sustainable construction through case studies and financial models can encourage stakeholders to make these investments.

6.3.4 Lack of Government/Political Support

With a relative importance index of 0.644, the lack of governmental and political support was identified as the fourth most important factor affecting sustainable construction in Ghana. This suggests that in Ghana, there is a need for stronger governmental intervention and political commitment to promote sustainable construction as indicated in previous studied by (Atombo, Dzantor & Agbo, 2015). Governmental support can take various forms, such as creating a clear policy guideline on green technologies and sustainable construction and empowering the Statutory authorities to enforce such laws. It is apparent there is a lack of governmental will to initiate change in this regard by offering financial incentives and subsidies to offset the higher initial costs of sustainable materials and technologies and leading by example in public construction projects. The Institutional Theory (Dacin et al., 2002) suggests that institutions, including governmental bodies and political frameworks, play a crucial role in shaping organisational behaviour and practices. The support from these institutions can be used to facilitate the adoption of sustainable construction practices. To address this barrier, it is important to develop a more robust government involvement in facilitating sustainable construction. Again, it might include setting clear sustainability standards, providing training for enforcement agencies, and establishing monitoring and evaluation mechanisms to track progress. Again, it is essential to develop comprehensive policies that support sustainable construction and ensure their effective implementation in the form of subsidies, tax incentives, or the development of regulations that encourage sustainable practices.

6.3.5 Lack of Public Awareness

With an RII of 0.636, lack of public awareness was ranked as the fifth most import factor that is a barrier to sustainability in Ghana. Lack of awareness and education can slow down the diffusion process acceptance of sustainability. Whilst public awareness closely relate education, this factor hinges on the ready information in the system on the issues surrounding substantiable construction technologies. The significant RII for lack of awareness/education indicates that many stakeholders may not be sufficiently informed about sustainable construction practices and their benefits (Ametepey et al., 2015b).

Sustainability is not only the responsibility of governments and the construction industry, but also the cooperate responsibility of all stakeholders in the built and social environment. Citizens need to get involved and be aware of the impacts of their behaviour, their use and misuse of resources. The participation of people is important to achieve the decisions needed to secure changes in the consumption patterns of the majority of the population. It is important to develop campaigns that on the one hand inform the public regarding the benefits and opportunities of the use of environmentally friendly building materials and products and, on the other, encourage a change in consumer habits towards a more sustainable use of resources. Generally, in Ghana, the use of sustainable materials for construction is not well perceived by the majority. People believe that these materials are of a backward origin and should not be used in modern construction. Public education on the importance of these materials both on the environment and the health of the people is the key to accepting sustainable construction. Again, issues surrounding the mining of aggregates, managing of water for construction related activities and consumption of timber as natural resources needs to be critically reflected on.

This barrier on lack of public awareness can be addressed through targeted educational programs and awareness campaigns. Interestingly when respondents were asked supplementary question on the SDGs, most of the professional lacked detailed information these global goals. Behavioural Change Theory emphasizes (Bandura, 1977) the importance of knowledge and awareness in changing behaviors. Lack of awareness about sustainable construction practices and their benefits can hinder adoption. It is recommended that there is the need for the implementing of comprehensive educational programs at various levels (from schools to professional training) to raise awareness. Additionally, public awareness campaigns highlighting the benefits of sustainable construction can drive behavioral change among stakeholders.

6.3.6 Lack of Technical Expertise

With an RII of 0.615, lack of technical expertise was ranked the 6th factor hindering sustainable construction technologies in Ghana. Evidently, one of the most critical barriers to sustainable construction in Ghana is the lack of capacity and technical expertise of the construction sector to actually implement sustainable practices. This lack of capacity is a factor both in the competence and availability of skill resources for such projects. The slow pace in the assimilation of sustainable construction is evidence of the lack of professional, tradesmen and labourers who have been trained to support sustainable construction. In reality, the capacity of the construction sector in many developing countries can barely deal with the demands of routine construction (Atombo et al., 2015). The vast majority of construction firms are small enterprises that rely on outsourcing personnel as and when required. This has severely affected skills training and the retention of expertise in the industry as construction workers become highly mobile, walking in and out of the industry, depending on performance in other sectors of the economy. The impact can be seen in the rigid adherence to management techniques and construction practices handed down from colonial times which, as a result of inadequate skills and capacity, have remained unchanged and irrelevant to the requirements of sustainable construction.

This gives the perception that Ghana lacks technical expertise who are professionally trained and skilled to drive the sustainability agenda in Ghana. Lack of technical expertise in sustainable construction can be a significant barrier to its adoption. The RII for lack of technical expertise highlights the need for building capacity within the construction industry. Without the necessary skills and knowledge, implementing sustainable construction practices can be challenging. This perception may be a hinderance for acceptance and adoption of sustainable construction technologies in Ghana. Human capital theories suggests that the skills and expertise of the workforce are critical for implementing advanced technologies and practices. The shortage of trained professionals in sustainable construction techniques can hinder progress and innovation. No doubt this has been a challenge in shoring the sustainable development agenda.

To over the above challenges, Competence-Based Theory (Verlag & Freiling, 2004) suggests that organizations need to develop specific competencies to be successful in meeting emerging competing technical and human resource demand. In the context of sustainable construction, technical expertise is a critical competency. This competency-based training may be initiated by stakeholders in the professional institutions such as the Ghana Institution of surveyors, Ghana Institution of Engineers, Ghana institute of Architects and the association of building and road contactors of Ghana for contractors who execute such projects. It is recommendations for the developing targeted training programs and certification courses for construction professionals that can help build the necessary technical expertise. Collaborations with academic institutions and industry experts can facilitate knowledge transfer and capacity building.

6.3.6 Resistance to Change

Based on the survey, the next factor being discussed as a barrier to sustainable construction is social-cultural challenge and resistance to change. Ghanaian artisans, contractors and clients are deeply ingrained with traditional construction technologies hence risk averse to exploding new technologies. Consistent with the Social Norms Theory, for the fear of the unknown, people may resist new sustainable (Lewin, 1947) uncertainty about their effectiveness and cost associated with future maintenance issues (Tina Dacin et al., 2002). Thus, social norms and cultural practices can significantly impact the acceptance and adoption of new practices, including sustainable construction. Thus, Lewin's change management model (Lewin, 1947) explain that resistance to change is a common institutional challenge. Overcoming this uncertainty requires an understanding and addressing the factors that make individuals or groups resistant to new practices. resistance requires effective communication, stakeholder engagement, and leadership support.

To overcome this fear, there would be the need to intensify public education to promote the awareness and benefits related to sustainability construction. Through stakeholder engagements, the government could deliberately plan the strategic implementation of sustainable construction projects within communities for trust and acceptance. Another way to drive cultural change is professional ownership, professional champions may be identifying and supporting local champions who can advocate for sustainable practices and influence social norms can facilitate the adoption of new practices. By addressing these barriers through targeted strategies and policies informed by relevant theories, Ghana can enhance the adoption and implementation of sustainable construction practices.

6.3.8 Lack of Building Codes and Policies

The final factor under discussions which is believed to a barrier to sustainable construction is the Lack of Building Codes and Regulation (with an RII of 0.600). even though in Ghana codes and regulations related to the built environment are hardly implemented to the latter, the absence of laws or codes related to the sustainability makes the agenda very difficult to achieve

In the absence of strict regulations and codes, there is little compulsion for the construction industry to adopt sustainable practices. The Institutional and Regulatory Theory (Dacin et al., 2002) suggests that the structures and norms established by institutions, including legal frameworks, significantly influence organizational behaviors and practices in guiding and controlling industry practices. Effective building codes and regulations are essential to ensure that sustainable construction practices are uniformly adopted and maintained. To overcome the above barrier, the government must as a matter of urgency establish and promulgate comprehensive building codes and regulations that mandate sustainable construction practices. This includes setting standards for energy efficiency, waste management, and the use of sustainable materials. Regular updates to these codes and strict enforcement mechanisms will ensure compliance.

7.0 A Conceptual Stakeholder Approach to managing the barriers of sustainable construction

It is evident that the challenges of sustainable construction technologies in Ghana are systemic and evidential. Nonetheless, it is imperative to note that overcoming the barrier to sustainable construction would require an integrate stakeholder approach. As proposed in the conceptual framework in figure 2 below, overcoming the barriers would require the integrated effort of the state, the statutory bodies, educational institutions, professional bodies, social actors and the general public. The conceptual model proposes that the stakeholder collaboration effort could effectively commence with a policy drive that would result in a mindset change, value change, social change and eventual corporate and societal benefit.

The gradual assimilation of sustainable construction practices would require the collaborate effort of the government enacting laws that promote sustainable construction and stipulating benefits to citizens who would implement practices on their projects. The government through tax holidays, tax reliefs and other waivers may encourage the possibility of the general public institutionalising sustainable construction practices such as green housing, recycling and reuse of construction waste, energy efficiency in buildings and lifecycle efficiency in buildings. Whilst the government enacts laws that promotes sustainable constriction practices, it is imperative for the statutory bodies such as the district and municipal assemblies also enforce laws that are punitive to those who degrade the environment through construction practices, causes air and water pollution, illegally dispose construction waste at unauthorised places or pollute the environment with wrongfully connection of sewage into the public drains. Apart from the statutory bodies enforcing the legislations, they also partner other agencies to the drive the sustainability agenda.

The drive towards sustainability cannot achieve the benefits required if the technical and manpower capacity of the nation is not enhanced through pedagogical transformation. Key to this achievement is the introduction of green models in all built environment programmes at the second cycle and tertiary level intuitions. This would produce the resultant effect of producing graduates who are technically inclined to issues of sustainability. Thus, modules on the design and construction of sustainable building, transport systems and civil engineering systems using sustainable materials, green buildings and green engineering must be introduced in all built environment courses at secondary and tertiary levels.

For effective stakeholder coordination the output from the academic institutions must be tied with the professional institutions such as the Ghana Institution of Engineers, Institution of Surveyors, Ghana Institution of Architects, Ghana Institution of planners, building civil engineering and road contractors, and various artisanal bodies. This would enhance the production of value change through periodic short courses, competency based professional training, and refresher courses to refresh and upskill the competence of professional stakeholders. This would again result in such professional introducing sustainability and green aspect to new constructions in Ghana.

To enhance a social change that would result in social embrace to a sustainable construction, there would be the need to deliberately include social actors such as the media, chiefs, opinion leaders and civil groups who would educate the general public on the benefit of sustainable construction. these stakeholders would trumpet the gains made through projects that had sustainable aspects introduced to it.

8.0 Conclusions and Recommendations

The primary objective of this research was to identify the barriers to sustainable construction and propose an integrated stakeholder model for managing the barriers to sustainable construction in Ghana. It has been established that activities of the built environment affect the economy, the ecology, the people therein hence requiring an integrated stakeholder effort to remove all barriers to sustainable construction and enhance the benefit thereof. Key barriers identified were related to lack of strategy, demand, high initial cost, lack of knowledge about green technologies, awareness and expertise and lack of government support. The prioritization of barriers as indicated by the RII suggests that efforts in Ghana to promote sustainable construction should focus on creating demand through public awareness, developing strategic initiatives, education and enhancing government support. Addressing these key areas could foster a more favorable environment for sustainable construction practices to flourish.

Since Ghanaian are resistant to systemic and cultural change, this research proposes that through an integrated stakeholder approach, change could result through the deliberate effort of the government, statutory bodies, educational institutions, professional bodies, social actors, civic societies, the media and the general public. This coordinated effort would be established through an iterative model aimed at producing policy promulgation, mindset change, value change and social change and change. This would ensure community penetration with the effect of a social acceptance. Through town hall discussions, community engagement, media discussions, professional seminars, skills training and workshops on sustainable construction, strategic awareness would be created, and knowledge would be shared to allay any fears resistance to change. Pedagogically, whilst the concept of principles of sustainable construction should be introduced to the educational modules in all built environment courses, CPD training and artisanal skill training should be introduced for all professionals and skilled workers.

Structurally, the government must set the pace by deliberately introducing sustainable construction technologies in al new projects and pilot these green building across the country through the regional blocks, ministries and the MMDAAs and provide tax reliefs for companies deliberately promoting sustainable construction practices.

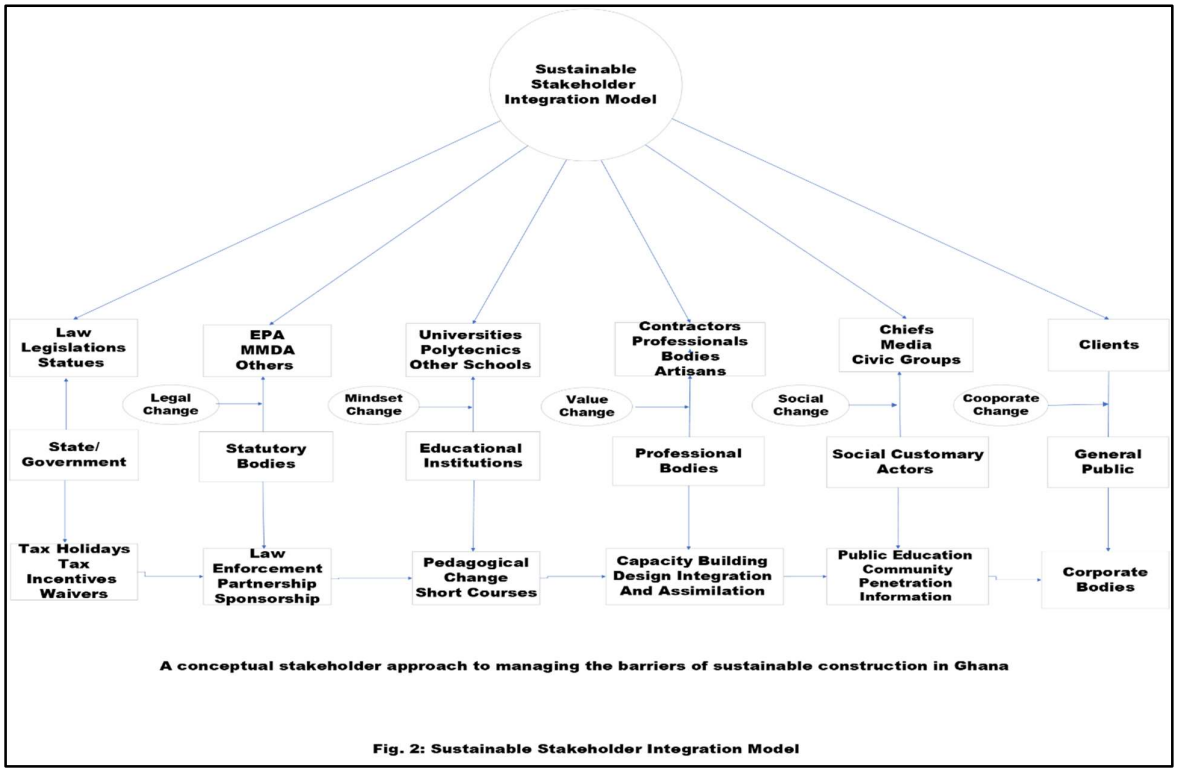

Fig. 2: Sustainable Stakeholder Integration Model

References

Abimbola, O.W. (2013), "Examination of Green Building Drivers in the South African Construction Industry: Economics versus Ecology", *Sustainability, 6(9)*. 6088–6106.

Adetunji, I., Price, A., Fleming, P. & Kemp, P. (2003), "Sustainability and the UK construction industry—a review", in *Proceedings of the Institution of Civil Engineers-Engineering Sustainability (Vol. 156, No. 4)*, Thomas Telford Ltd. 185–199.

Ahadzie, D.K., Proverb, D.G., Olomolaiye, P.O., & Ankrah, N.A. (2009), "Competences required by managers for housing construction in Ghana-Implications for CPD agenda", *Emerald, 16(4).* 16(4).

Ahn, Y.H., Pearce, A.R., Wang, Y. & Wang, G. (2013a), "Drivers and barriers of sustainable design and construction: The perception of green building experience", *International Journal of Sustainable Building Technology and Urban Development*. 4(1):35–45.

Ahn, Y.H., Pearce, A.R., Wang, Y. & Wang, G. (2013b), "Drivers and barriers of sustainable design and construction: The perception of green building experience", International Journal of Sustainable Building Technology and Urban Development. 4(1).

Akinshipe, O., Oluleye, I.B. & Aigbavboa, C. (2019), "Adopting sustainable construction in Nigeria: Major constraints", in *IOP Conference Series: Materials Science and Engineering*, vol. 640, Institute of Physics Publishing. DOI: 10.1088/1757-899X/640/1/012020.

Alghamdi, H., Shoukry, H., Abadel, A.A. & Khawaji, M. (2023), "Performance assessment of limestone calcined clay cement (LC3)-Based lightweight green mortars incorporating recycled waste aggregate", *Journal of Materials Research and Technology*. 23:2065–2074. DOI: 10.1016/j.jmrt.2023.01.133.

Ametepey, S.O., Gyadu-Asiedu, W. & Assah-Kissiedu, M. (2015a), "Sustainable Construction Implementation in Ghana: Focusing on Awareness and Challenges".

Ametepey, S.O., Gyadu-Asiedu, W. & Assah-Kissiedu, M. (2015b), "Sustainable construction implementation in Ghana: Focusing on awareness and challenges", *Civil and Environmental Research*. 72(2):109–119.

Araújo, A.G., Carneiro, A.M.P. & Palha, R.P. (2020), "Sustainable construction management: A systematic review of the literature with meta-analysis", *Journal of Cleaner Production*. 256(120350).

Arogundade, S., Dulaimi, M. & Ajayi, S. (2024), "Exploring the challenges impeding construction process carbon reduction in the UK", *International Journal of Construction Management*. 24(4):422–431.

Atombo, C., Dzantor, J.C.K. & Agbo, A.A. (2015), "Integration of Sustainable Construction in Project Management: A Case Study in Ghana", *International Journal of Construction Engineering and Management*. 4(1).

Aytekin, B. & Mardani-Aghabaglou, A. (2022), "Sustainable Materials: A Review of Recycled Concrete Aggregate Utilization as Pavement Material", *Transportation Research Record*. 2676(3):468–491. DOI: 10.1177/03611981211052026.

Bandura, A. (1977), "*Self-efficacy: Toward a Unifying Theory of Behavioral Change"*.

Bhavani, S. & Prasad, M.L.V. (2023), "A low carbon cement (LC3) as a sustainable material in high strength concrete: green concrete", *Materiales de Construccion*. 73(352). DOI: 10.3989/mc.2023.355123.

Bond, S. & Perrett, G. (2012), "The key drivers and barriers to the sustainable development of commercial property in New Zealand", Journal of sustainable real estate". *Journal of sustainable real estate*. 4(1):48–77.

Bourdeau, L. (1999), "Sustainable development and the future of construction: a comparison of visions from various countries", *Building Research & Information*. 27(6):354–366.

Bourdeau, L., Huovila, P. & Lanting, R. (1998), "Sustainable development and the future of construction", a CIB W82 project., in *World Building Congress*. 1187–1196.

Buertey, J.T.I. & Adjei-Kumi, T. (2012), "Cash management in the construction industry: The case of Ghana", *Pentvars Business Journal*. 6(1):6581.

Buertey, J.I.T., Amofa, D. & Atsrim, F. (2016), "Stakeholder Management on Construction Projects: A Key Indicator for Project Success", *American Journal of Civil Engineering*. 4(4):117. DOI: 10.11648/j.ajce.20160404.11.

Buertey, J.I.T., Offei, S.W., Adjei Kumi, T. & Atsrim, F. (2018), "Effect of aggregates minerology on the strength of concrete: Case study of three selected quarry products in Ghana", *Journal of Civil Engineering and Construction Technology*. 9(1):1–10. DOI: 10.5897/jcect2017.0472.

Buertey, J.I.T., Doe, D.A., Atsrim, F. & Sarfo, F. (2023), "Managing Construction Project Constraints: Towards an Integrated Risk Management Hub for Efficient Project Delivery", *Services for Science and Education-United Kingdom*. 11(5):373–392. DOI: 10.14738/aivp.115.15726.

Buertey, J.T., Dadadzogbor, E. & Atsrim, F. (2021), "Procurement path influencing factors in Ghana: managing the challenge of cultural shift", *International Journal of Construction Management*. 21(1):78–92. DOI: 10.1080/15623599.2018.1508803.

Carlander, J. & Thollander, P. (2023), "Barriers to implementation of energy-efficient technologies in building construction projects—Results from a Swedish case study", *Resources, Environment and Sustainability*. 11(100097).

Centobelli, P., Cerchione, R., Ertz, M. & Oropallo, E. (2023), "What we learn is what we earn from sustainable and circular construction", *Journal of Cleaner Production*. 382:135183.

Chan, A.P.C., Darko, A., Olanipekun, A.O. & Ameyaw, E.E. (2018), "Critical barriers to green building technologies adoption in developing countries: The case of Ghana", *Journal of Cleaner Production*. 172:1067–1079. DOI: 10.1016/j.jclepro.2017.10.235.

Cheer-Germ, G., Jun-Ren, T., Jen-Hao, C., Cheng-Tung, C. & Yue-Lin, H. (2012), "Fire-resistance property of reinforced lightweight aggregate concrete wall", *Construction and Building Materials*. 30:725–733. Available: https://doi.org/10.1016/j.conbuildmat.2011.12.081Get rights and content [2023, August 25].

Council, U.G.B. (1996), "Sustainable building technical manual: green building design, construction, and operations".

Dacin, M.T., Goodstein, J. & Scott, W.R. (2002), "Institutional theory and institutional change: Introduction to the special research forum", *Academy of Management Journal*. 45(1):45–57.

Danquah, J.A. (2021), "*Production of Affordable but Quality Housing for the Low-Income Urban Dweller "Promoting the Use of Local Building Materials"*, Kumasi- Ghana. Available: www.statsghana.gov.gh.

Dhandapani, Y., Sakthivel, T., Santhanam, M., Gettu, R. & Pillai, R.G. (2018), "Mechanical properties and durability performance of concretes with Limestone Calcined Clay Cement (LC3)", *Cement and Concrete Research*. 107:136–151. DOI: 10.1016/j.cemconres.2018.02.005.

Dosumu, O.S. & Aigbavboa, C.O. (2021), "Drivers and effects of sustainable construction in the South African construction industry", *Acta Structilia*. 28(2):78–107. DOI: 10.18820/24150487/as28i2.4.

Esezobor, E.L. (2016), "*Sustainability and Construction: A Study of the Transition to Sustainable Construction Practices in Nigeria"*.

Ghosh, S.K. (2020), "Waste management under the legal framework in India", *In Sustainable Waste Management Challenges in Developing Countries (IGI Global)*. 144–165.

Haberberg, A. & Rieple, A. (2020), *Strategic management: Theory and application*." London: Oxford University Press.

Hair, J.F., Bush, R.P. & Ortinau, D.J. (2003), "*Marketing research: Within a changing information environment".* McGraw-Hill.

Häkkinen, T., & Belloni, K. (2011), "Barriers and drivers for sustainable building", *Building Research & Information*. 39(3):239–255.

Hoff, K. & Stiglitz, J.E. (2000), "Modern economic theory and development", in, Oxford: Oxford University Press. 389–485.

Huovila, P.E.K.K.A. (1998), "Sustainable construction in Finland in 2010", Vtt Building Technology, *National report*.

Ifije, O. & Aigbavboa, C. (2020), "Identifying Barriers of Sustainable Construction: A Nigerian Case Study", *MATEC Web of Conferences*. 312:04004. DOI: 10.1051/matecconf/202031204004.

Ive, G.J. & Gruneberg, S.L. (2000), "*The Economics of the Modern Construction Sector"*. vol. 1. London: Macmillan Pres Ltd.

Kats, G. & Alevantis, L. (2003), "The costs and financial benefits of green buildings: a report to California's sustainable building task force. Sustainable Building Task Force".

Kibert, C.J. (2003), "Sustainable Construction at the Start of the 21st Century", *Int. E-Journal Constr*. 1–7.

Kibert, C.J. (2016a), "*Sustainable construction: green building design and delivery*", London: John Wiley & Sons.

Kibert, C.J. (2016b), "*Sustainable construction: green building design and delivery"*, London: John Wiley & Sons.

Kuffo, M.A., Ewusie Jnr., I., Newton-Akpor, R., Ahiadu, A.A., Kesse, S. & Appiah, T.J. (2023), "*Housing deficit in Ghana"*.

Lewin, K. (1947), "*Lewin's change management model: Understanding the three stages of change"*, New York: Harper & Row.

Lima, L., Trindade, E., Alencar, L., Alencar, M. & Silva, L. (2021), "Sustainability in the construction industry: A systematic review of the literature", *Journal of Cleaner Production*. 289(125730).

Luo, W., Sandanayake, M., Hou, L., Tan, Y. & Zhang, G. (2022), "A systematic review of green construction research using scientometrics methods", *Journal of Cleaner Production*. 366(132710).

Malhotra, R., Behal, M., Choudhary, Y. & Kaushik, T. (2021), "*Circular Built Environment Highlights from Asia Policies", Case studies and UN2030 Agenda Indicators*.

Maqbool, R. & Amaechi, I.E. (2022), "A systematic managerial perspective on the environmentally sustainable construction practices of UK", *Environmental science and pollution research*. 29(42):64132–64149.

Mavi, R.K., Gengatharen, D., Mavi, N.K., Hughes, R., Campbell, A. & Yates, R. (2021), "Sustainability in construction projects: A systematic literature review". MDPI. DOI: 10.3390/su13041932.

Nawaz, A., Chen, J. & Su, X. (2023), "Exploring the trends in construction and demolition waste (C&DW) research: A scientometric analysis approach", *Sustainable Energy Technologies and Assessments*. 55(102953).

OECD. "Environment directorate. (2003), "Environmentally sustainable buildings: challenges and policies",*OCDE.*

Oke, A., A.D., A.C., & M.Z. (2021), "Environmental sustainability: Impact of construction activities, In Collaboration and Integration in Construction, Engineering, Management and Technology", in *Proceedings of the 11th International Conference on Construction in the 21st Century, London 2019*, London: Springer International Publishing. 229–234.

Opoku, A. & Fortune, C. (2011), "The implementation of sustainable practices through leadership in construction organizations", *Management*. 11456–1154.

Opoku A. & Fortune, C. (2015), "Environmental, Cultural, Economic, and Social Sustainability", *Annual Review.*

Osuizugbo, I.C., Oyeyipo, O., Lahanmi, A., Morakinyo, A. & Olaniyi, O. (2020a), "Barriers to the adoption of sustainable construction", *European Journal of Sustainable Development*. 9(2):150–162. DOI: 10.14207/ejsd.2020.v9n2p150.

Osuizugbo, I.C., Oyeyipo, O., Lahanmi, A., Morakinyo, A. & Olaniyi, O. (2020b), "Barriers to the adoption of sustainable construction", *European Journal of Sustainable Development*. 9(2):150–162. DOI: 10.14207/ejsd.2020.v9n2p150.

Pennell, A., Suresh, S. & Chinyio, E. (2013), "*A Critical Review of the Barriers to the Integration at Site Level of Sustainability Practices into Uk Construction Projects".*

Perera, S., Opoku, D.G.J. & Rodrigo, N. (2022a), "Technological advancements in green and sustainable construction", The Construction Industry: Global Trends". *Job Burnout and Safety Issues*. 51–74.

Perera, S., Opoku, D.G.J. & Rodrigo, N. (2022b), "Technological advancements in green and sustainable construction. The Construction Industry", *Global Trends, Job Burnout and Safety Issues*. 51–74.

Persson, J., & Grönkvist, S. (2015), "Drivers for and barriers to low-energy buildings in Sweden", *Journal of cleaner production*. 109:296–304.

Raymond J. Cole. (2005), "Building environmental assessment methods: redefining intentions and roles", *Building Research & Information*. 33(5):455–467.

Redclift, M. (2005), "Sustainable development (1987–2005): an oxymoron comes of age", *Sustainable development*. 13(4):212–227.

Rogers, E.M., Singhal, A. & Quinlan, M.M. (2014), "Diffusion of innovations, in *An integrated approach to communication theory and research"*, Routledge. 432–448.

Shelbourn, M.A., Bouchlaghem, D.M., Anumba, C.J., Carrillo, P.M., Khalfan, M.M. & Glass, J. (2006), "Managing knowledge in the context of sustainable construction", *Journal of Information Technology in Construction*. 11:57–71.

Shurrab, J., Hussain, M. & Khan, M. (2019), "Green and sustainable practices in the construction industry: A confirmatory factor analysis approach", *Engineering, Construction and Architectural Management*. 26(6):1063–1086.

Sjostrom, C., & Bakens, W. (1999), "CIB Agenda 21 for sustainable construction: why, how and what", *Building Research & Information*. 227(6):347–353.

Statistical Service of Ghana. (2021), "*Population Housing Census of Ghana"*, Accra.

Tafazzoli, M. (2018), "Accelerating the green movement: Major barriers to sustainable construction. 54th ASC Annual International Conference Proceedings", Associated Schools of Construction.

Takyi, S.A., Amponsah, O., Duamor, S.N., Azunre, G.A. & Ahadzie, D.K. (2002), "An assessment of regulatory compliance and residents' perceptions of the siting of telecommunication masts: Insights from a rapidly urbanising Ghanaian city", *African Geographical Review*. 41(4):411–432.

Tina Dacin, M., Goodstein, J. & Richard Scott, W. (2002), "Institutional theory and institutional change: Introduction to the special research forum", *Academy of management journal*. 45(1):45–56.

Tomkiewicz, H.S. (2011), "Barriers to implementation of sustainable construction practices in the homebuilding industry: a case study of Rochester", NY.

Tunmise, A.T. & Abimbola, O.A. (2015), "Implementation of sustainable development: the impact of social sustainability", in *International Conference on Intelligent Agriculture (Vol. 63, No. 16)*. 139–142.

Tzschentke, N., Kirk, D. & Lynch, P.A. (2004), "Reasons for going green in serviced accommodation establishments", *International journal of contemporary hospitality management*. 16(2):116–124.

Udomsap, A.D. & Hallinger, P. (2020), "A bibliometric review of research on sustainable construction", 1994–2018. *Journal of Cleaner Production*. 254:120073.

Verlag, R.H. & Freiling, J. (2004), "*A competence-based theory of the firm"*, Rainer Hampp Verlag. Available: https://hdl.handle.net/10419/78932.

Wallbaum, H. & Buerkin, C. (2003), "Concepts and instruments for a sustainable construction sector", *Industry and environment,* 26(2):53–57.

Yamane, T. (1967), "*Statistics, An Introductory Analysis"*, 2nd ed. vol. 46. New York: Harper and Row.

Yin, B.C.L., Laing, R., Leon, M. & Mabon, L. (2018), "An evaluation of sustainable construction perceptions and practices in Singapore", *Sustainable Cities and Society*. 39:613–620. DOI: 10.1016/j.scs.2018.03.024.

Zainul, A.N. (2010), "Investigating the awareness and application of sustainable construction concept by Malaysian developers", *Habitat International*. 34(4):421–426. DOI: 10.1016/j.habitatint.2009.11.011.

Zhu, X., Jinzhong Yang, Qifei Huang & Tao Liu. (2022), "A Review on Pollution Treatment in Cement Industrial Areas: From Prevention Techniques to Python-Based Monitoring and Controlling Models", *Processes 10, no. 12: 2682.* 10(12):2682. Available: https://doi.org/10.3390/pr10122682 [2024, April 29].

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