THE INTEGRATION OF GREEN BUILDING TECHNOLOGIES INTO THE CONSTRUCTION SECTOR OF DEVELOPING COUNTRIES: THE CASE OF GHANA

Nana Genfi[1&3] and Serik Tokbolat[2&3]

[1] *GRAHAM Group, 11 Old Jewry, London, EC2R 8DU, UK*

[2] *Department of Civil Engineering, University of Nottingham, Nottingham, NG7 2RD, UK*

[3] *School of Architecture, Design and the Built Environment, Nottingham Trent University, 50 Shakespeare Street, Nottingham, NG1 4FQ, UK*

Emerging climate change crisis, resources scarcity and global sustainability agenda are putting pressures on developing nations and demanding actions. This study aimed to examine the significance of introducing green building technologies (GBTs) in construction projects in Ghana by conducting a literature review and identify key drivers, barriers, and promotion strategies for their implementation based on a survey conducted among stakeholders relevant to the Ghana's construction sector. The research revealed that (1) government-linked barriers are critical barriers to GBTs adoption, (2) environmental and health-related drivers have a significant impact on the implementation of GBTs and (3) effective communication strategies and public support from the government through the introduction of regulations and standards were established as essential promotion strategies to the effective integration of GBTs in Ghana. All participating stakeholders would prefer to see GBTs integrated into the construction industry.

Keywords: barriers; drivers; green building; strategies; sustainable; Ghana

INTRODUCTION

The growing population and increased urbanization have triggered a steady growth in the construction sector (Anaman and Osei-Amponsah, 2007). The expansion of the worldwide economy thrives on the extraction and consumption of natural resources which generate waste and emissions that threaten the environment (Cotgrave and Riley, 2013). Pachauri and Meyer (2014) asserted that developed countries have immensely benefitted from fossil fuels, however, the end products of these fossil fuels such as greenhouse gases endanger the environment. The built environment is responsible for about 40% of worldwide energy consumption and use of resources which, in turn, negatively affect the well-being of the environment and humans (Yates *et al.,* 2015; Mawat *et al.,* 2019; Masia *et al.,* 2020). Common views are shared by Twumasi-Ampofo *et al.,* (2012) and Djokoto *et al.,* (2014) on the nature of processes

[2] serik.tokbolat@nottingham.ac.uk

Genfi, N and Tokbolat, S (2023) The Integration of Green Building Technologies into the Construction Sector of Developing Countries: The Case of Ghana *In:* Tutesigensi, A and Neilson, C J (Eds) *Proceedings of the 39th Annual ARCOM Conference,* 4-6 September 2023, University of Leeds, Leeds, UK, Association of Researchers in Construction Management, 810-819.

adopted in the construction environment in developing countries contributing to high energy use, environmental pollution, etc. At present, green technologies are widely discussed across various industries as viable solutions to the issues and can be applicable in construction projects.

GBTs are concerned with the use of efficient building materials and construction practices to ensure the minimal use of energy and apply sound management practices to promote waste and water efficiency which are also among the main GB principles (Richardson and Lynes, 2007; Glavinich, 2008). Integration of GBTs lead to the optimum consumption of energy and water and their application in construction promotes the efficient use of natural resources. To meet the sustainability goals the integration of green technologies is the way forward due to technologies such as efficient water heating, energy-efficient HVAC systems, solar technologies, building orientation optimisation technologies, etc. which allow designers to achieve minimal energy use. To improve sustainable construction within the industry, newer technologies and methods have emerged such as Building Information Modelling, lean construction, value engineering, life-cycle assessment, etc. which impact project design and collaboration (Oke *et al.,* 2018).

There is the need for cooperation from all stakeholders across different stages of construction, who should make environmentally friendly decisions and choose energy efficient solutions and practices. If stakeholders do not consider aligning with green construction policies and processes, the consequences could be negative to the ecosystem (Sharma, 2018).

This study aimed to examine the significance of introducing green technologies in construction projects in Ghana and identify key drivers, barriers, and strategies for their implementation. This was carried out by (1) assessing the views of stakeholders in Ghana on aspects hindering the adoption of GBTs as well as drivers of their successful integration; (2) examining the availability of a legal basis for integration of green buildings and GBTs in Ghana, and (3) evaluate the effects of various strategies to promote the integration of such technologies.

LITERATURE REVIEW

The construction industry of Ghana is in the process of addressing the growing demand for residential, industrial as well as commercial spaces, while still preserving the physical environment of the country and social welfare by adopting principles of sustainable development (Ahmed *et al.,* 2014). Ghana is a slow, upcoming market in Africa. The progress of the country is partly supported by the outputs of the construction industry (Assibey-Mensah,2009; Ahmed *et al.,* 2014). Recently, the construction has been one of the fastest-advancing business directions in Ghana and it was found to be the key contributor to economic growth (Osabutey *et al.,* 2013).

There was also no specific government legislation found to support GBTs implementation in Ghana, so the concept of GBTs is seen to be down to the stakeholders' option. Anzagari *et al.,* (2019) reported that, the industry is burdened with planning challenges and a lack of sustainability standards, despite the current regulations in the industry meant to manage the practices of the construction stakeholders. Thus, there is a need to integrate the concept of sustainability to improve the industry and reduce the negative environmental impacts.

In the Ghanaian construction market, the demand for innovative construction has been low which creates an obstacle to the adoption of GBTs (Addy *et al.,* 2020).

According to Ahn *et al.,* (2013) and Chan *et al.,* (2017), among the top obstacles to green construction in the United States, for example, are lengthy payback times, the propensity to retain existing procedures, limited skills and experience of subcontractors, higher prices of renewable goods and resources, resistance to reform and the absence of government incentives. In Singapore, in turn, poor commitment and coordination among the project team, high costs of green tools and materials, indifference from clients and market demand, etc. were all established as barriers (Hwang and Tan, 2012).

A study in Hong Kong by Zhang *et al.,* (2012) described high maintenance costs, lack of incentives, limited knowledge, etc. as the most important hurdles to the integration of comprehensive GB systems. According to Winston (2010), insufficient construction legislation, as well as a lack of experience and skills, are obstacles to sustainable housing growth in Ireland. As other countries have different laws, a thorough comprehension of the obstacles to GBTs acceptance in specific countries is needed as it will aid in overcoming barriers and support the use of GBTs (Aktas and Ozorhon, 2015).

According to Agyekum *et al.,* (2020), among the drivers identified during interviews with some members of relevant professional bodies are observability of the advantages of green-certified buildings, incorporation into professional bodies' code of conduct, governmental commitment, public recognition, green building certification rewards, policies and legislation. Other critical considerations, such as "set rules and regulations" and "green design requirements and building specifications," were also evaluated in the results. Also, economic conditions continue to have a significant influence (Agyekum *et al.,* 2020).

According to Hwang *et al.,* (2017), some viable results to encourage the implementation of GBTs in business parks in Singapore are green growth strategies and respective legislation, government co-funding and incentives, and partnering with academic organizations to analyse the effects of GBTs integration in business parks. Hwang and Tan (2012) acknowledged the schemes which boost the GB acceptance, including the education of clients about GB benefits, expanding the scope of government incentives to include GBTs adoption, the use of construction tours as a form of education to the public and the development of a GB project management structure.

METHOD

A quantitative research strategy was adopted as an optimal approach in this study, requiring robust data to be collected from construction-related experts using a survey and assessing it applying statistical analysis (Johnson and Onwuegbuzie, 2004; Fellows and Liu, 2015). This research implemented a non-probability sampling approach in determining the sample size as there is no data on the availability of sustainability-related experts in Ghana and it was deemed to be difficult to assess the population size. A similar methodology was used by Owusu-Manu *et al.,* (2018) where the use of this technique helped to obtain an effective sample size and minimise bias often linked with the sampling technique.

The survey questionnaire was used as it was seen as the best tool to gather the opinions of many construction stakeholders and to ensure objectivity (Tan, 2011). The questionnaire has been formulated to evaluate the themes discussed above and comprised the following sections shown in Table 1.

Table 1: Sections of the questionnaire survey

Sr. No	Sections under the Questionnaire
1	Letter to Participants
2	Background Information of Participant including their organisational position and profession
3	Perception About the Benefits of GBTs in the construction Industry of Ghana
4	Barriers to GBT implementation
5	Drivers for GBT implementation
6	Promotional strategies for the implementation of GBTs

The questionnaire contained mostly close-ended questions with its length designed not to exceed 15-minute engagement time, with straightforward answers in some sections and some answers structured into categories and values for evaluation using 5-point Likert scale where respondents are asked to evaluate the level of agreement on the defined parameters. Zhang *et al.,* (2011) emphasised the use of the Likert scale for evaluating the comparative relevance of distinct factors based on the views of survey participants. In this study, the Likert scale was used to denote "1" as "Not important" to "5" as "Very important".

Prior to distributing the questionnaire, a pilot study was undertaken to wholly assess this approach regarding the design of the questionnaire, ensuring all relevant themes are captured in the survey research as well as tweaking the content to incorporate the use of five options which will be evaluated using the 5-point Likert scale. This pilot study was achieved with the aid of an experienced professor and a knowledgeable researcher in the subject of sustainability to undertake a content validity assessment of the draft questionnaire ensuring all terminologies are easily understood and the appropriate technical words are included.

Data Collection

Due to COVID-19 Pandemic limitations, the drop-and-pick method was not feasible so only the web-based survey via google forms was used. The link was shared with survey respondents through e-mails, referrals, and social networks using a snowball sampling approach due to limited access to a sampling frame as well as their knowledge and willingness to partake in the study (Owusu-Manu *et al.,* 2018). The target population for this research was the construction stakeholders within Ghana.

56 responses were received when the survey concluded. A review of the survey feedback showed six were incomplete and hence, omitted leaving 50 responses. Out of the targeted 114 respondents, only 50 responses were used indicating a response rate of 43.9%. The slow integration of sustainability in the Ghana also contributed to the participation of a few experienced professionals in the survey. According to Ott and Longnecker (2010), the response rate is higher than the recommended value of 30% which implies that this sample size is considered valid for the central limit theorem. Also, Nulty (2008) asserted the difficulty in ensuring the participation of survey respondents, as well as their reluctance, could result in lower response rates from online surveys.

Data Analysis

From the questionnaire, the feedback from the respondents was entered into Microsoft Excel spreadsheets, other analytical tools employed for this study were descriptive analysis and mean score ranking approach.

FINDINGS

From the survey, in terms of educational background, 4% of participants have a PhD, 62% have a master's degree, 32% with a bachelor's degree with just 2% with elementary school background. There is a fair representation of different construction stakeholder types as evidenced by 60% as consultants, 26% as contractors, 10% as developers with 2% in government and the same in urban water supply which shows diversification in survey research. Based on their professional designations, there was higher participation by engineers with 58%, 14% being architects, 14% being project managers, 2% participation each by clients, construction managers and quantity surveyors and 8% being site supervisors.

72% of the respondents are aware of green technology with 16% unfamiliar with this concept. Only 14% have just over 6 years of experience in green buildings with the majority having lesser years of experience in this concept as shown by 54% with no experience in green buildings. This explains why GBT adoption has been extremely slow in Ghana. Also, it is worth noting from the survey analysis that 94% of the respondents are keen to see the implementation of GBTs in this construction environment, due to a few green developments in Ghana recently and this aspect of the survey aided in improving the reliability of the obtained results.

In ranking the theme variables of barriers, driving forces and strategies, the most popular descriptive statistics of mean and standard deviation were used to rate them in order of importance as seen by the participants (Mao *et al.,* 2015). According to Mao *et al.,* (2015), where two or more variables share the same mean score, the higher score is assigned to the variable with the least standard deviation value. This was used in evaluating the research data for the theme variables to the implementation of GBTs. The rankings established based on the statistical analysis using mean and standard deviation are subjective based on the feedback expressed by the survey respondents and their understanding of the sustainable themes used in the questionnaire.

Barriers

Based on the 17 barriers used in the questionnaire, the responses for each barrier as evaluated by the Likert scale. The mean and standard deviation were established for each barrier and ranked using the mean score ranking approach. As all the mean scores for the barriers exceeded 3, it implies all the barriers have significant importance and mitigation measures must be employed to improve the adoption of GBTs. The top-ranked barriers, as identified by the respondents, were the absence of policies and regulations for green building, unfamiliarity of GBTs and their benefits, lack of initial capital to support GBTs, lack of political commitment, non-existence of GBTs database as well as the absence of GB training programmes for project staff. The respondents felt the top barriers are linked to government, economic and knowledge related elements which imply sustainable construction is obstructed due to a combination of factors such as the accessibility of information and the readiness of the market. Darko *et al.,* (2018) affirmed the importance of government-linked barriers as they hinder the implementation of GBTs and this is also emphasised by Djokoto *et al.,* (2014), who reported the absence of government backing has affected the integration of sustainable construction. The interventions from government can improve stakeholder motivation and encourage GBT implementation through incentives and provision of GB policies and regulations. Also, effective communication strategies such as heightened public awareness and GB workshops can lead to successful integration of GBTs in Ghana. These results of cost and

knowledge-linked barriers may be because the survey respondents felt the strategies of financial support and training programmes can aid in the successful adoption of GBTs and address the barriers.

Drivers

The drivers in the questionnaire were identified as a result of extensive literature review as well as professional opinion and the effectiveness of the drivers are evaluated based on the feedback from the respondents using descriptive statistical analysis.

It can be established from the analysis that the top-ranked drivers from the survey are minimal environmental impact, enhanced indoor environmental quality, the conservation of non-renewable resources, enhanced occupancy comfort, devising a standard for innovative construction as well as minimal consumption of materials in construction. The respondents agreed the top drivers are environmental and social related elements but that notwithstanding, all the drivers in the questionnaire are significant as their mean score values exceeded 3 which is the middle value on the Likert scale.

The results from this study may be because sustainable construction in Ghana is at its inception stage and has not been fully accepted by all and there is still a general unawareness about the benefits GBTs offer. The essence of environmental and health-related drivers stems from the fact that the respondents feel there is a gradual depletion of natural resources due to unsustainable construction practices and feel a change in the methodology of construction will mitigate the adverse environmental impact and promote efficiency in the use of resources.

Strategies for promotion

In supporting the implementation of GBTs, the effectiveness of the strategies identified in the questionnaire have been evaluated based on the feedback of the survey participants and these strategies may include resources and platforms which are essential to improve the adoption of GBTs on a national level.

The top-ranked strategies from the analysis are media publicity, the use of workshops and seminars for public environmental awareness, proper enforcement of GB policies once developed, the introduction of green rating and labelling programs as well as public acknowledgement and rewarding schemes for GBT adopting companies. With an overall mean score higher than 4, it implies all the strategies listed are rated 'important' and must be considered for the promotion of GBTs. The essence of evaluating these strategies in order of importance allows stakeholders to appreciate which ones require more focus towards GBTs implementation. The respondents felt effective communication strategies, in conjunction with, public support from government through the introduction of regulations and policies, will activate the drive towards sustainable construction and nullify the identified key barriers from the survey. This reflects the consistency in their feedback and contributes to the reliability of the survey. Table 2 illustrates the highly ranked barriers, drivers and promotion strategies.

CONCLUSIONS

GBT implementation in Ghana is influenced by knowledge, cost and risk-related factors which have a major adverse effect on its application. This research aimed at investigating the themes involved in the GBT adoption and the use of the

questionnaire survey allowed the collection and analysis of data using mean score ranking technique as well as statistical analysis to evaluate the level of awareness and how GBTs can be adopted.

Table 2: Highly ranked barriers, drivers, and promotion strategies to the adoption of GBTs

Rank	Barriers to GBTs Adoption
1	Absence of policies and regulations for green building
2	Unfamiliarity of GBTs and their benefits
3	Lack of initial capital to support GBTs
4	Lack of political commitment
5	Non-existence of database and information about GBTs
6	Absence of GB training programmes for project staff
7	Absence of rating systems and labelling programs for green buildings
8	Inadequate local institutes and facilities to support GBTs
9	Reluctance to switch from the use of traditional technologies
10	No backing from senior management on the use of GBTs
Rank	Drivers for GBT Integration
1	Minimal environmental impact
2	Enhanced indoor environmental quality
3	Conservation of non-renewable resources
4	Enhanced occupancy comfort
5	Devising a standard for innovative construction
6	Minimal consumption of materials in construction
7	Advancement in the efficiency of GBTs
8	Increased building value
9	Reduced whole lifecycle costs
10	New technology and information systems
Rank	Strategies to Promote GBTs Integration
1	Media publicity (e.g., print media, audio-visual media, social media campaign)
2	The use of workshops and seminars to create public environmental awareness
3	Proper enforcement of green building policies
4	The introduction of green rating and labelling programs
5	Public acknowledgement and rewarding schemes for companies that use GBTs
6	Training programmes on GBTs for project stakeholders
7	Accessibility of corporate framework for effective adoption of GBTs
8	Support from public institutions such as Environmental Protection Agency on the use of GBTs
9	Accessibility of adequate information on the importance of GBTs
10	Strict GB regulations and guidelines

This research evaluates the survey results on the variations in themes to GBT adoption in Ghana where the criticalities of the identified drivers, barriers and strategies have been assessed from the perspective of the local construction stakeholders. From the survey results, it was deduced (1) government-linked barriers are significant barriers to GBTs adoption, (2) environmental and health-related drivers will contribute immensely to the implementation of GBTs in Ghana and (3) effective communication strategies through the use of workshops and media publicity and public support from

government were established as major promotion strategies to the integration of GBTs in Ghana.

It is imperative for academic and professional bodies who are among the key stakeholders and are required to play a vital part in terms of promoting environmental awareness and insight on green building technologies. Besides, a conducive environment offered by the government demonstrating a commitment to sustainability through the provision of guidelines and incentives to admonish local firms to be innovative and achieve GBT expectations. Notwithstanding the achievement of the research goals, some of the research limitations were the inadequate sample size, limited experts on sustainability, and the low response rate of the construction stakeholders to the questionnaire survey as a higher response rate could have enhanced the credibility and reliability of the findings collected. Another limitation of the study is related to the fact that the term GBTs is rather too generic encompassing a wide range of technologies and principles. The further studies should consider specific technologies or sustainable construction measures and associated aspects driving or hindering their implementation.

REFERENCES

Addy, M, Adinyira, E, Danku, J C and Dadzoe, F (2021) Impediments to the development of the green building market in sub-Saharan Africa: The case of Ghana, *Smart and Sustainable Built Environment*, **10**(2), 193-207.

Agyekum, K, Adinyira, E, Ampratwum, G (2020) Factors driving the adoption of green certification of buildings in Ghana, *Smart and Sustainable Built Environment*, **9**(4), 595-613.

Ahmed, K, Hatira, L and Valva, P (2014) *How Can the Construction Industry in Ghana Become Sustainable?* Masters Thesis, Department of Strategic Sustainable Development, Faculty of Engineering, Blekinge Institute of Technology,

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

Aktas, B and Ozorhon, B (2015) Green building certification process of existing buildings in developing countries: cases from Turkey, *Journal of Management and Engineering*, **31**(6).

Anaman, K and Osei-Amponsah, C (2007) Analysis of the Causality Links between the growth of the Construction industry and the growth of the Macro-Economy in Ghana, *Construction Management and Economics*, 25(**9**), 951-961.

Anzagira, L F, Duah, D and Badu, E (2019) A conceptual framework for the uptake of the green building concept in Ghana, *Scientific African*, ***6***, 00191.

Assibey-Mensah, G O (2009) Ghana's Construction industry and global competition: A research note, *Journal of Black Studies*, **39**(6), 974-989.

Chan, A P C, Darko, A, Ameyaw, E E, and Owusu-Manu, D (2017) Barriers affecting the adoption of green building technologies, *Journal of Management and Engineering*, **33**(3).

Cotgrave, A and Riley, M (2013) *Total Sustainability in the Built Environment*, Basingstoke: Palgrave Macmillan.

Djokoto, S, Dadzie, J and Ohemeng-Ababio, E (2014) Barriers to sustainable construction in the ghanaian construction industry: Consultants perspective, *Journal of Sustainable Development*, **7**(1), 134.

Fellows, R F and Liu, A (2015) *Research Methods for Construction 4th Edition*, Chichester: Wiley-Blackwell.

Field, A (2013) *Discovering Statistics Using IBM SPSS Statistics, 4th Edition*, London: Sage.

Glavinich, T E (2008) *Contractor's Guide to Green Building Construction: Management, Project Delivery, Documentation and Risk Reduction*, Chichester: John Wiley and Sons

Hwang, B G and Tan, J S (2012) Green building project management: Obstacles and solutions for sustainable development, *Sustainable Development*, **20**(5), 335-349.

Hwang, B G, Zhu, L and Tan, J S H (2017) Green business park project management: Barriers and solutions for sustainable development, *Journal of Cleaner Production*, **153**, 209-219.

Johnson, R B and Onwuegbuzie, A J (2004) Mixed methods research: A research paradigm whose time has come, *Educational Researcher*, **33**(7), 14-26.

Masia, T, Kajimo-Shakantu, K and Opawole, A (2020) A Case Study on the implementation of green building construction in Gauteng province, *South Africa Emerald Institute*, **31**(3).

Mawat, M J, Dawood, A S and Alhasan, Z M (2019) A brief review of the Environmental Assessment of Green Building in Developing Countries, *International Journal of Novel Research in Engineering and Science*, **6**(1), 7-15.

Nulty, D D (2008) The adequacy of response rates to online and paper surveys: What can be done? *Assessment and Evaluation in Higher* Education, **33**, 301 - 314.

Oke, A, Aghimien, D, Aigbavboa, C and Musenga, C (2018) Drivers of sustainable construction practices in the Zambian construction industry, *Energy Procedia*, **158**, 3246-3252.

Osabutey, E L C, Williams, K and Debrah, Y A (2013) The potential for technology and knowledge transfers between foreign and local firms: A study of the construction industry in Ghana, *Journal of world business*, **49**(4), 560-571.

Ott, R L and Longnecker, M (2010) *An Introduction to Statistical Methods and Data Analysis*, Belmont, CA: Brooks/Cole.

Owusu-Manu, D G, Edwards, D J, Kukah, A S, Parn, E A, El-Gohary, H and Hosseini, M R (2018) An empirical examination of moral hazards and adverse selection on PPP projects, *Journal of Engineering, Design and Technology*, **16**(6), 910-924.

Pachauri, R K and Meyer, L A (2014) *Climate Change, 2014 Synthesis Report; Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Geneva, Switzerland: IPCC, 1059-1072.

Richardson, G R A and Lynes, J K (2007) Institutional Motivations and Barriers to the Construction of Green Buildings on Campus: A case study of the University of Waterloo, Ontario, *International Journal of Sustainability*, **8**(3), 339-354.

Sharma, M (2018) Development of a 'Green building sustainability model' for green buildings in India, *Journal of Cleaner Production*, **190**, 538-551.

Tan, W C K (2011) *Practical Research Methods*, Singapore: Pearson Custom

Twumasi-Ampofo, K, Osei-Tutu, E, Decardi-Nelson, I and Abroakwa, O P (2012) A model for reactivating abandoned public housing projects in Ghana, *Civil and Environmental Research*, **6**(3), 6-16.

Winston, N (2010) Regeneration for sustainable communities? Barriers to implementing sustainable housing in urban areas, *Sustainable Development*, **18**(6), 319-330.

Yates, A, Green, E and Hope, T (2015) *Sustainable Infrastructure: Sustainable Buildings*, ICE Publishing

Zhang, X, Shen, L and Wu, Y (2011) Green strategy for gaining competitive advantage in housing development a China study, *Journal Cleaner Production*, **19**(2), 157-167.

Zhang, X, Shen, L, Tam, V W and Lee, W W (2012) Barriers to implement extensive green roof systems: A Hong Kong study, *Renewable and Sustainable Energy Reviews*, **16**(1), 314-319.

Zhao, X, Hwang, B G and Low, S P (2013) Critical success factors for enterprise risk management in Chinese construction companies, *Construction and Management Economics*, **31**(12), 1199 - 1214.