Contents Lists Available At sddubidsjplm.com

Journal of Planning and Land Management

Journal homepage: www.sddubidsjplm.com

DOI:10.36005/jplm.v4i1.178

Drivers of the implementation of Green Building concepts and technologies in developing countries: The case of Ghana

[1]Anzagira, L. F., [2]Duah, D., [3]Badu, E., & [4]Simpeh, E. K

[1] Department of Civil Engineering, Faculty of Engineering, Dr. Hilla Limann Technical University, Wa, Ghana. Corresponding Author: leefelix611@gmail.com
[2] Department of Architecture, Kwame Nkrumah University of Science & Technology, PMB, Kumasi, Ghana.
[3] Department of Construction Technology & Management, Kwame Nkrumah University of Science & Technology, PMB, Kumasi, Ghana.
[4] Centre for Settlements Studies, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

A R T I C L E I N F O

Article history:
Received: April 30, 2025
Received in revised form: July 10, 2025
Accepted: July 22, 2025

Keywords:
Construction industry; Drivers; Ghana; Green building; Sustainability; Sub-Saharan Africa

A B S T R A C T

Green building (GB) is a widely endorsed strategy in terms of addressing goals 12 and 13 of the Sustainable Development Goals (SDGs). Nonetheless, available literature suggests that little attention has been given to drivers influencing the adoption of green building concepts and technologies in developing countries of Sub-Saharan Africa (SSA). This paper aims to determine the drivers influencing the adoption of green building concepts and technologies and to assess the extent of consensus amongst built environment professionals regarding the drivers. The study employed a quantitative approach involving the use of a questionnaire survey administered to purposively selected construction professionals in Ghana to collect the data. A total of 292 valid responses were received, resulting in a response rate of 52%. Descriptive analysis was then employed to compute the means and relative importance indices (RII) with the aim of determining the most important drivers of GB. Subsequently, a parametric test (ANOVA) was conducted to interrogate the extent of consensus amongst the professionals regarding the drivers. The survey results revealed that the top five most important drivers propelling the uptake of GB in Ghana are: greater energy-efficiency of buildings; enhancement of occupants' health and comfort and satisfaction; greater water-efficiency of buildings; better indoor environmental quality, and thermal comfort (better indoor temperature). A Comparison of the views of the different professional groups among the stakeholders also revealed that, Architects consistently rated all drivers more highly than other professionals, except in the case of 'improving national economic performance and job creation,' where quantity surveyors assigned it greater importance. This study has provided empirical evidence of the important drivers influencing the adoption of green building concepts and technologies from all stakeholders. It would also serve as a knowledge repository for built environment stakeholders in developing countries.

1. Introduction

Globally, activities of the construction industry have gained publicity for their environmental impacts and the consumption of natural resources. These impacts have far reached effects, yet the need for construction is increasing hence, the degradation, exploitation of the resources and generation of waste by the construction industry (CI) persists. Green building (GB) is widely regarded as a very suitable response to the negative effects of buildings and construction activities on the climate and environment. In the face of the numerous challenges that are militating against the implementation of green building practices, it still thrives on the basis of the numerous benefits accruing from GB adoption as well as the actions of governments and institutions.

Stakeholders' decision to implement or invest in green buildings results from some coercions and expectations. The motivations (both benefits and external influences) that lead individuals or institutions to adopt GB practices is referred to as GB drivers and have been reported widely in literature to include the benefits and actions outside the benefits that lead to green implementation by stakeholders (Darko et al., 2017). Various authors (e.g. Falkenbach et al. 2010; Ahn et al. 2013; Mulligan et al. 2014; Windapo and Goulding 2015; Darko et al. 2017; Kumah et al. 2022; Periyannan et al. 2023) reported that stakeholders are persuaded by factors such as the need to conserve water and energy, improve their marketability, meet regulatory requirements, and attract some incentive packages amongst others. It is however evident that, these studies on GB drivers have focused primarily on specific countries with the developed countries dominating the spectrum against their developing country counterparts. In the view of Qi et al. (2010), it is necessary to have a deeper understanding of the drivers of GB peculiar to a particular locality in order to encourage widespread adoption since it would influence decision making of stakeholders. As such, it is necessary that the GB drivers particular to the Ghana construction industry are examined.

Limited studies have been conducted to examine GB drivers in the Ghanaian construction industry (GCI). While the study of Agyekum et al. (2020) on drivers for green certification of buildings in Ghana was limited to only 10 built environment (BE) professionals in Kumasi, the study of Kumah et al. (2022) covered only BE professionals in Kumasi and Accra of Ghana. Also, the study of Darko et al. (2017) was limited to 43 GB experts in Accra. However, Ghana notably has a very active construction industry with a variety of stakeholders (BE professionals, Developers, Policy makers, and Academia) hence it is insufficient to limit opinions regarding GB adoption to only BE professionals and GB experts who already know about and are adopting GB practices and also to only the two cities of Kumasi and Accra out of the 16 administrative capitals of Ghana. This study therefore aims to address this gap by determining the important drivers to GB adoption as well as their influences on GB adoption across a broad spectrum of stakeholders in the construction industry across all the sixteen (16) administrative regions of the country through empirical means. The study stands as the first empirical study incorporating the views of a comprehensive range of stakeholders in the GCI across all the 16 regions of Ghana; the findings of which will be useful to policy makers, industry practitioners as well academia as it would help them promote GB adoption. It also contributes to the body of knowledge through the empirical consensus arrived at.

2. Literature review

Available literature reveals that, the drivers of GB adoption can be classified into different groups, including but not limited to the following: environmental-related; resource efficiency-related; health and well-being-related, and socio-economic-related drivers. These groups are derived based on similar classifications in literature (e.g. Falkenbach et al. 2010; Darko et al. 2017).

2.1 Environmental-related drivers

Environmental concerns are put across as one of the foremost reasons stakeholders adopt green building practices. Construction activity widely acknowledged to negatively impact the environment by consumption of resources and emissions of greenhouse gases. It is widely reported that added to construction industry's resource consumption, it releases also 35-40% of global CO_2 and produces up to 65% of waste materials dumped in landfills (United Nations Environment Programme (UNEP) 2007; Wu and Low 2010; Son et al. 2011; AlSanad 2015). Zuo et al. (2015) support the assertion that the CI is a major contributor to CO_2 emissions because it utilizes a substantial quantity of energy globally. Green buildings, by their design and construction offer enormous potential for energy savings and thus reduces the environmental impacts of building since most of the emissions are as a result of energy consumption. The studies by Manoliadis et al. (2006), Abidin and Pownya (2014), Djokoto et al. (2014), and Love et al. (2012) all confirmed that environmental impact reduction is a key driving force for stakeholders to adopt GB practices. In the study by Manoliadis et al. (2006) in India, it was also reported that, stakeholders implement GB practices to conserve the scarce and limited non-renewable resources available. Resource conservation was ranked among the top five drivers in that study. Darko et al. (2017) confirms this finding in their study in Ghana reporting that the adoption of GB practices ensures the sustainable use of natural and non-renewable resources such as lands and minerals. Additionally, in their studies in Ghana both Kumah et al. (2022) and Agyekum et al. (2022) report environmental concerns and the conservation of resources as primary reasons why built environment professionals are willing to pay for GBs. This implies that environmental-related drivers pertain to both developed and developing countries albeit to varying degrees.

2.2 Resource efficiency-related drivers

In relation to resource conservation are energy saving or energy efficiency, water efficiency and material efficiency of buildings which have been discovered to be an important motivator for stakeholders to implement Green Building Technologies (GBTs). In response to increasing utility bills, stakeholders have resorted to the application of energy saving technologies and Windapo (2014) in corroboration reported that, in South Africa, stakeholders incorporate green building principles in their projects as a response to rising energy costs. The application of GBTs such as green wall technology in building development saves about 33% - 60% of operational energy of the building likewise the application of energy efficient windows saves on about 14 – 20% operational energy (Balaras et al., 2007). Similarly, Wong (2012) notes that, the application of LED bulbs can save 70 – 80% of electricity. The development of buildings that are energy efficient is an important tool for national development given the significant quantities of energy consumed by buildings. Several studies including Manoliadis et al. (2006), Ahn et al. (2013), Darko et al. (2017), Luo et al. (2017), and Periyannan et al. (2023) among others who have all reported that energy efficiency is the most important driver for adopting GB practices. Periyannan et al. (2023) actually notes that considering financial viability, all the implemented green retrofits such as Solar PV systems have a positive return on investment and less than ten years of payback period; a key reason why stakeholders in Sri Lanka implement GBTs. Ahn et al. (2013) reported the key drivers of GB adoption as resource conservation, waste reduction, and water conservation. An international survey of GB experts by Darko et al. (2017) and Darko, Chan, Owusu-Manu, et al. (2017) also reported that water-efficiency, was one of the top drivers of GBTs implementation.

2.3 Health and well-being-related drivers

The application of GB practices such as natural lighting and cross ventilation together with other technologies for enhancing the air quality in a building significantly improves and protects the health and comfort of the occupants (Kats, 2003). This is attractive to many stakeholders and they are reported to implement GB practices as a result of this. Thatcher and Milner (2016) reported that health and well-being in green building is a vital reason why stakeholders adopt GB. Humans spend up to 90% of the time indoors (World Health Organisation (WHO), 2015) and as such, poor indoor conditions pose serious health problems such as illnesses, frequent sick leaves, absenteeism and depression among others for the occupants (Kats, 2003). As a result, GB practices that help to improve these conditions attracts stakeholders to implement. This finding is corroborated by several studies including Darko, Chan, Gyamfi, et al. 2017; Ahn et al. 2013; Gou et al. 2013; Windapo, 2014 among others. Edwards (2006) revealed that green offices in the UK increase the productivity of employees by 2-3% due to the improved workplace environment which in turn lessens employee absenteeism. Love et al. (2012) study in Australia also revealed improve occupants' health and well-being as one of the important drivers for GB practices adoption.

2.3 Socio-economic-related drivers

There is literature in support of socio-economic related factors that are driving the uptake of GB practices in several countries across the globe. Low et al. (2014) showed that the important drivers for greening new and existing buildings in Singapore are return on investments, local and overseas competitions, rising energy bills, corporate social responsibility, and marketing/branding motive. Also, in China, the study by Zhang et al. (2011a) revealed that building up green reputation and good image, gaining competitive advantage, commitment on corporate social responsibility, reduction in construction costs, developing unique green products, and reduction in operation and maintenance costs are important factors driving the application of green technologies in the Chinese construction industry. Love et al. (2012) study in Australia also revealed the drivers for GB practices adoption as marketing strategies, reduction in whole-life cycle costs, marketing and landmark development, and attract premium clients and high rental returns. In Chile, Serpell et al. (2013) found the most important drivers to be corporate image, cost reduction, and market differentiation. In South Africa, Windapo (2014) found that, rising energy costs, competitive advantages and legislation are the key drivers to GB adoption. The studies of Periyannan et al. (2023) and Agyekum et al. (2022) in Sri Lanka and Ghana respectively both corroborate the above findings with a high return on investment being the topmost driver of GB adoption and financing respectively. As observed earlier, these divers are global cutting across both developed and developing countries and hence a further study encompassing all stakeholders of the construction industry is necessary. Table 1 below summarises the various drivers identified in literature and the authors. These drivers were then adopted and reviewed for the questionnaire survey in this study.

Table 1: Summary list of drivers of green building concepts and technologies

Drivers of adopting GBCs & Ts	References
Reduced lifecycle costs of buildings	Love et al. (2012); Zhang et al. (2011a); Darko et al. (2017); Aktas and Ozorhon (2015)
Greater energy-efficiency of buildings	Manoliadis et al. (2006); Augenbrose and Pearce (2009); Darko et al. (2017); Darko, Chan, Owusu-Manu et al. (2017); Windapo (2014); Low et al. (2014); (Ahn et al. 2013); Luo et al. (2017); Aktas and Ozorhon (2015); Periyannan et al. (2023)
Greater water-efficiency of buildings	Darko et al. (2017); Darko, Chan, Owusu-Manu et al. (2017); Ahn et al. (2013); Devine and Kok (2015); Aktas and Ozorhon (2015)
Enhanced occupants' health and comfort and satisfaction	Darko et al. (2017); Darko, Chan, Owusu-Manu et al. (2017); Love et al. (2012); Kats (2003); Thatcher and Milner (2016); Devine and Kok (2015); UNEP (2009); Bond (2010); Aktas and Ozorhon (2015)
Increased overall staff productivity	Edwards (2006); USGBC (2003); Bond (2010); Park and Yoon (2011); Darko et al. (2017)
Reduced environmental impacts of buildings	Manoliadis et al. (2006); Love et al. (2012); Gou et al. (2013); Abidin and Pownya (2014), Djokoto et al. (2014); Wang et al. (2014); Darko et al. (2017); Darko, Chan, Owusu-Manu et al. (2017); Ahn et al. (2013); Augenbrose and Pearce (2009); Kumah et al. (2022)
Better indoor environmental quality	Ahn et al. (2013); Windapo (2014); Kats (2003); Park and Yoon (2011); UNEP (2009); USGBC (2013); Augenbrose and Pearce (2009), Aktas and Ozorhon (2015); Darko et al. (2017); Periyannan et al. (2023)
Good company image and reputation	Serpell et al. (2013); Darko et al. (2017); Darko, Chan, Owusu-manu et al. (2017); Windapo (2014); Zhang et al. (2011a); Low et al. (2014); Love et al. (2012)
Enhanced marketability (or marketing benefits)	Love et al. (2012); Low et al. (2014); Darko et al. (2017); Agyekum et al. (2020); Tran et al. (2020)
High return on investment	Bond, & Perrett (2012), Low et al. (2014), Devine and Kok (2015), Darko et al. (2017); Agyekum et al. (2022); Periyannan et al. (2023)

Better workplace environment	Bond (2010); USGBC (2003); Park and Yoon (2011); Darko et al. (2017)
Thermal comfort (better indoor temperature)	Kats (2003); Aktas and Ozorhon (2015); Darko et al. (2017)
Better rental income and increased lettable space	Bond & Perrett (2012); Love et al. (2012); Devine and Kok (2015); Darko et al. (2017)
Attract premium clients and increased property values	Windapo (2014); Love et al. (2012); Devine and Kok (2015)
Reduced construction and demolishing wastes	Manoliadis et al. (2006); Augenbrose and Pearce (2009); Ahn et al. (2013)
Preservation of natural resources and non-renewable fuels/energy sources	Manoliadis et al. (2006); Augenbrose and Pearce (2009); Ahn et al. (2013); Darko, Chan, Owusu-Manu et al. (2017); Agyekum et al. (2022)
Sets standards for future design and construction	Darko, Chan, Owusu-Manu et al. (2017); Li et al. (2013)
Reduced use of construction materials (materials-efficiency)	Ahn et al. (2013); Zhai et al. (2014); Agyekum et al. (2022)
Attracting quality employees and reduced employee turnover	Edwards (2006); Bond (2010); Devine and Kok (2015)
Corporate social responsibility	Zhang et al. (2011); Bond & Perrett (2012); Low et al. (2014); Aktas and Ozorhon (2015); Darko et al. (2017); Tran et al. (2020)
Facilitating a culture of best practice sharing	Darko et al. (2017); Mondor et al. (2013)
Efficiency in construction process and management practices	Darko et al. (2017); Zhai et al. (2014); Mondor et al. (2013)
Improved performance of national economy and job creation	Li et al. (2013); Darko et al. (2017); Tran et al. (2020)

3. Methodology

The research was carried out using a structured three-stage approach to achieve the study's objectives. The desk study, comprising the review of literature was undertaken during the first stage of the study. Germane literature with respect to the drivers of green building uptake in the construction industry was reviewed and subsequently categorised into different groups. The review of literature aided in developing a framework to summarize the list of drivers of adopting green building into a total of 23 drivers to address the gaps in research identified through the review process.

In the second stage, a quantitative approach was employed involving the use of a structured questionnaire survey administered to selected construction professionals to collect the data. The survey instrument for this study was designed based on the findings of the literature review carried out. This instrument was then used to collate the views of Ghana construction industry stakeholders in this study. The questionnaire was compiled to solicit the background information of respondents and to assess the drivers of green building adoption. Closed-ended questions were utilised for this study as there is proof that it would likely increase response rate (Rowley, 2014). In an instance or two, open-ended questions were allowed especially for the background information related questions. The five (5)-point Likert scale which has gained prominence in green building research (e.g. Simpeh & Smallwood 2020; Hwang et al. 2017; Chan et al. 2018) was used in this study to assess the drivers of green building adoption. Participation in the questionnaire survey was voluntary and confidentiality was maintained in line with institutional ethical guidelines.

Built environment professionals such as architects, quantity surveyors, engineers, project and construction managers working with consultancy firms, contractors, property developers and academia constituted the population for the study. Based on the database of the different built environment professionals (such as the Ghana Institute of Architects, Ghana Institution of Engineering, Ghana Institution of Surveyors, and Ghana Real Estate Development Agency among others), the total population in terms of registered professionals was 6500. Hence the sample size was computed based on the population using the formula of Czaja and Blair (1996) and Creative Research Systems (2003). It is important to highlight that a sample size of five hundred and sixty-four (564) was obtained. Following the determination of the sample size, the purposive and snowball sampling techniques were adopted in selecting the sample strata. The rationale for adopting these sampling methods is because this study seeks to assess the drivers to adoption of GB based on the views and experiences of stakeholders who can speak to the subject matter. Furthermore, green building is an emerging concept in the Ghanaian construction industry and as such, there is limited information on it and the number of individual and organizational stakeholders involved is gradually rising but not in a manner that the entirety of them can be determined easily. There was a total of 292 valid responses, resulting in a response rate of 52%. This response rate is relatively high as compared to similar green building studies (e.g. Darko et al. 2018; Simpeh and Smallwood 2020; and Nani, 2009), and thus validates the response rate of the study.

The collected data were subjected to various analysis using SPSS Version 25 during the third stage of the study. The first analysis was to rank the important drivers based on their mean score and RII; and the second was to perform ANOVA to check if there was variation in the agreement ratings of the drivers among the professional backgrounds of the respondents. The RII values typically range from 0 to 1, where higher values (closer to 1 – >0.6) signify greater importance, values ranging from0.4 – 0.6 signify medium importance, and lower values (closer to 0 - <0.4) indicate less importance. Prior to analysing the data, the dataset was tested for reliability and normality using Cronbach's alpha coefficient test. This was to check the consistency of the 23 drivers and their scale. The computed Cronbach's alpha value from the data set was 0.945 which is greater than the recommended value of 0.70 (Wong et al. 2016; Eybpoosh et al. 2011; Oyedele, 2013) suggesting a good internal consistency and the reliability of the data obtained from the field survey and as a result, the five-point scale system was reliable for further analysis. The study findings then underwent a rigorous discussion. See figure 1 below for a graphical illustration of the research process as explained.

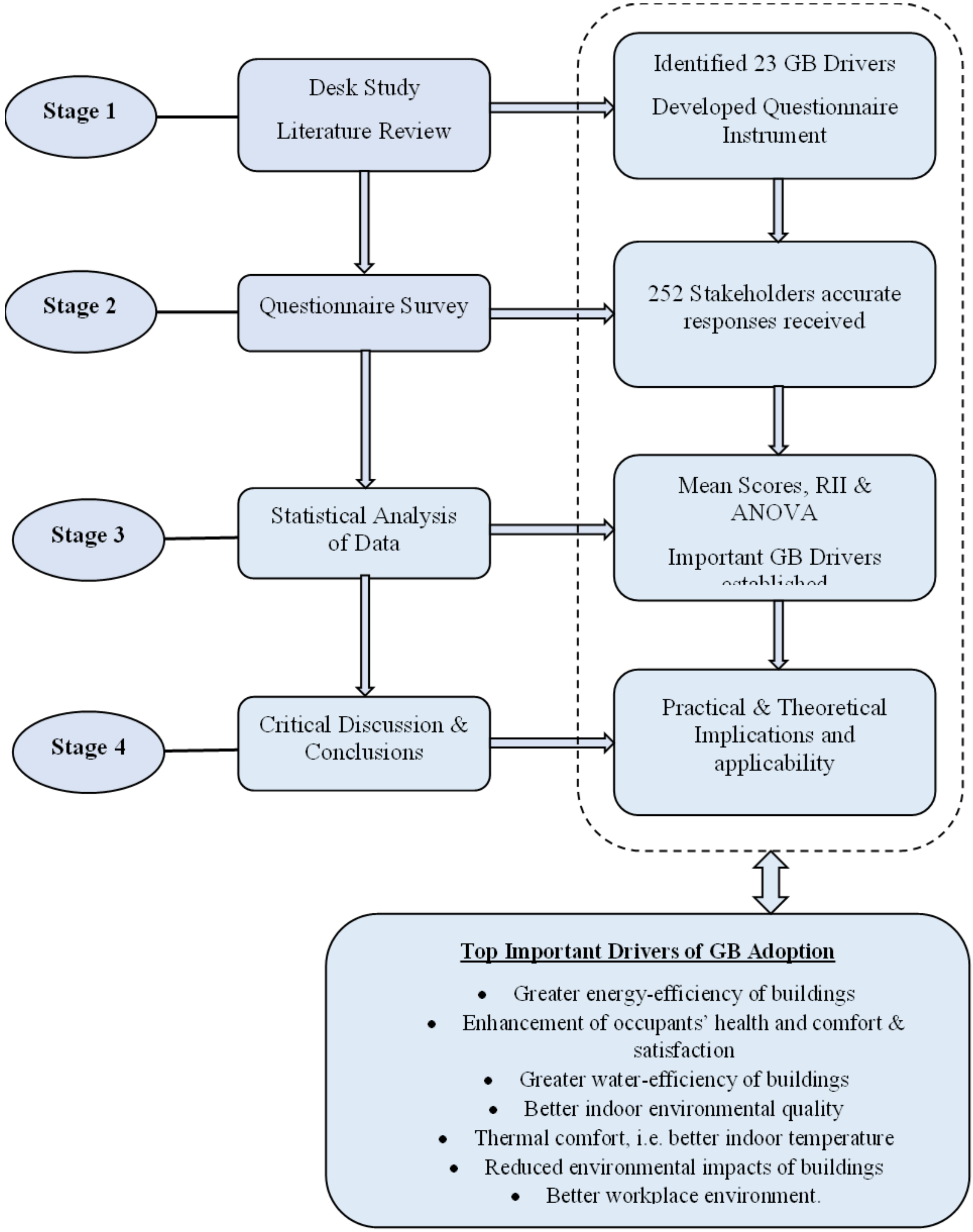

Figure 1: Graphical illustration of research process

4. Interpretation and presentation of findings

4.1 Respondents' background information

The background information of the respondents was analysed using descriptive statistics and the results were presented using frequency distribution and percentages. The information included the professional background of the respondents, their current place of employment or type of firm/organization, years of experience in construction and their location within the country Ghana. Table 2 summarizes the background information of the survey respondents.

Table 2: Background information of respondents

Socio-demographic	Frequency	Percentage (%)
Professional background		
Architect	138	47.26
Quantity Surveyor	69	23.63
Engineer (all categories)	53	18.15
Other	19	6.51
Project/Construction manager	13	4.45
Total	292	100
Type of firm/organization		
Contractor	33	11.3
Consultant	129	44.2
Developer	25	8.6
Government department/Ministry/Regulator	29	9.9
Academic/research institution	60	20.5
Industry Association	6	2.1
Other	10	3.4
Total	292	100
Years of experience in construction		
1-5 years	117	40.1
6-10 years	88	30.1
11-15 years	63	21.6
16-20 years	12	4.1
Over 20 years	12	4.1
Total	292	100
Type of organization you deal with		
Both	110	37.67
Public sector	128	43.84
Private sector	54	18.49
Total	292	100
Location within the country Ghana		
Coastal Belt	118	40.4
Middle Belt	106	36.3
Savanna Belt	68	23.3
Total	292	100.0

The results showed that the respondents comprised of different professional backgrounds with a significant proportion of respondents (47.3%) being architects, suggesting a strong representation of design professionals in this study. The heterogeneous and diverse backgrounds of the respondents as witnessed ensures the reliability and quality of the responses collected. Furthermore, the results show that, 11.3%, 44.2%, 8.6%, and 9.9% were from contractor, consultant, developer, and Government department/Ministry/Regulator organizations respectively while 20.5%, 2.1%, and 3.4% were obtained from Academic/research institutions, Industry Associations, and others (finance, business etc.) respectively. The result is a reflection of the inclusion of all Ghana construction industry stakeholder categories to ensure validity of the study as well as its generalization.

In relation to the experience levels of the respondents in the survey, the results 40.1% had 1-5 years working experience. It worth noting that, majority (59.9%) of the respondents have at least six (6) years (i.e. > 5 years, 6-10 years, 11-15 years, 16-20 years and over 20 years) of experience in the GCI.

From a practical perspective of the Ghana construction industry, this result is indicative that, survey respondents have adequate experience hence plausibly concluding that, they have sufficient knowledge-based experience to offer valid and reliable responses in the survey. By way of location of the respondents within the country, the results indicate that, they were spread over the country with majority (40.4%) being in the coastal belt and 36.3% in the Middle belt. This is largely reflective of the real situation in Ghana as most of the construction activity takes place in the urbanized cities of Accra (coastal belt) and Kumasi (middle belt). Both Amoah et al. (2010) and Ofori-Kuragu et al. (2016) reported that most construction work happens in these cities.

4.2 Important drivers of green building concepts and technologies adoption

Drivers are factors or catalysts that propel the actions of stakeholders to embrace and implement green building concepts and technologies (GBCTs). This section of the study seeks to determine the important drivers for the uptake of green building concepts and technologies in the Ghanaian building industry. To achieve this objective, 23 drivers (Table 1) were identified from the literature review stage of the study. In the questionnaire, a five-point Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Slightly Agree; 4 = Agree; 5 = Strongly Agree) where respondents were asked to rate their level of agreement with each of the 23 drivers was used.

Table 3 presents a summary of the survey results regarding the drivers of GBCTs uptake in the Ghana construction industry. Noticeably, the mean scores of the agreement that these are the main drivers for GBCTs uptake are very high ranging from 4.42 to 3.55. These scores are all above the average agreement of "3=slightly agree". The consistently high mean scores indicate widespread professional consensus on the importance of these drivers to promote the uptake of GBCTs in Ghana. From Table 3, the results show that the top five drivers to increase the uptake of GBCTs in Ghana are; "greater energy-efficiency of buildings (4.42)", "enhancement of occupants' health and comfort and satisfaction (4.36)", "greater water-efficiency of buildings (4.34)", "better indoor environmental quality (4.27)", and "thermal comfort (better indoor temperature) (4.23)". Also significantly rated were "reduced environmental impacts of buildings (4.19)" and "better workplace environment (4.19)". In addition, preservation of natural resources and non-renewable fuels/energy sources, reduced lifecycle costs of buildings, sets standards for future design and construction and good company image and reputation were significantly rated with mean scores above 4.0. In effect, the study had identified eleven significant drivers (mean scores ranged from 4.01 to 4.42 with relatively low standard deviation showing less variability of response) as shown in Table 3 which are deemed important for propelling the uptake of GBCTs in Ghana. On the other hand, the least ranked drivers were; "Enhanced marketability (3.81)", "Improved performance of national economy and job creation (3.8)", "Better rental income and increased lettable space (3.71)", "Corporate social responsibility (3.6)", and "Attracting quality employees and reduced employee turnover (3.55)".

From the foregoing, the top most important drivers of GBCTs adoption are;

- Greater energy-efficiency of buildings (4.42)
- Enhanced occupants' health and comfort and satisfaction (4.36)
- Greater water-efficiency of buildings (4.34)
- Better indoor environmental quality (4.27)
- Thermal comfort (better indoor temperature) (4.23)
- Reduced environmental impacts of buildings (4.19)

The least ranked drivers included;
Enhanced marketability (or marketing benefits) (3.81)
Improved performance of national economy and job creation (3.8)
Better rental income and increased lettable space (3.71)
Corporate social responsibility (3.6)
Attracting quality employees and reduced employee turnover (3.55)

Table 3: Descriptive statistics for drivers influencing the implementation of GBCTs

Drivers	N	Mean	Std. Dev.	RII	Mean Ranking
Greater energy-efficiency of buildings	289	4.42	0.83	0.884	1
Enhanced occupants' health and comfort and satisfaction	289	4.36	0.875	0.872	2
Greater water-efficiency of buildings	289	4.34	0.876	0.868	3
Better indoor environmental quality	289	4.27	0.849	0.854	4
Thermal comfort (better indoor temperature)	287	4.23	0.884	0.846	5
Reduced environmental impacts of buildings	287	4.19	0.874	0.838	6
Better workplace environment	289	4.19	0.803	0.838	6
Preservation of natural resources and non-renewable fuels/energy sources	289	4.17	0.907	0.834	8
Reduced lifecycle costs of buildings	288	4.14	1.038	0.828	9
Sets standards for future design and construction	289	4.14	0.958	0.828	9
Good company image and reputation	289	4.01	0.88	0.802	11

Reduced construction and demolishing wastes	289	3.99	0.946	0.798	12
High return on investment	289	3.96	0.914	0.792	13
Increased overall staff productivity	289	3.91	0.936	0.782	14
Attract premium clients and increased property values	289	3.89	0.995	0.778	15
Facilitating a culture of best practice sharing	289	3.87	0.974	0.774	16
Reduced use of construction materials (materials-efficiency)	287	3.86	1.05	0.772	17
Efficiency in construction process and management practices	289	3.84	0.961	0.768	18
Enhanced marketability (or marketing benefits)	288	3.81	1.017	0.762	19
Improved performance of national economy and job creation	286	3.8	0.967	0.76	20
Better rental income and increased lettable space	289	3.71	0.97	0.742	21
Corporate social responsibility	288	3.6	0.979	0.72	22
Attracting quality employees and reduced employee turnover	288	3.55	1.018	0.71	23

4.3 Professional differences in GBCTs driver perceptions (ANOVA Results)

There was statistically significant difference in the agreement level of the respondents' professional background on the ratings of the drivers to the uptake of green building concepts and technologies. As shown in Table 4, no statistically significant difference was observed among professional groups for the following four drivers; enhanced marketability (or marketing benefits), better rental income and increased lettable space, facilitating a culture of best practice sharing, and efficiency in construction process and management practices, with respective p-values > 0.05 (0.073, 0.059, 0.083, 0.072).

Table 4: ANOVA for professional background and drivers

		Sum of Squares	df	Mean Square	F	Sig.
Reduced lifecycle costs of buildings	Between Groups	28.544	4	7.136	7.091	0.000
	Within Groups	275.722	274	1.006		
	Total	304.265	278			
Greater energy-efficiency of buildings	Between Groups	10.897	4	2.724	4.138	0.003
	Within Groups	181.046	275	0.658		
	Total	191.943	279			
Greater water-efficiency of buildings	Between Groups	11.236	4	2.809	3.938	0.004
	Within Groups	196.161	275	0.713		
	Total	207.396	279			
Enhanced occupants? health and comfort and satisfaction	Between Groups	11.736	4	2.934	3.912	0.004
	Within Groups	206.26	275	0.75		
	Total	217.996	279			
Increased overall staff productivity	Between Groups	10.091	4	2.523	2.946	0.021
	Within Groups	235.495	275	0.856		
	Total	245.586	279			
Reduced environmental impacts of buildings	Between Groups	11.047	4	2.762	3.696	0.006
	Within Groups	203.961	273	0.747		
	Total	215.007	277			
Better indoor environmental quality	Between Groups	9.52	4	2.38	3.342	0.011
	Within Groups	195.851	275	0.712		
	Total	205.371	279			
Good company image and reputation	Between Groups	14.194	4	3.548	4.788	0.001
	Within Groups	203.792	275	0.741		
	Total	217.986	279			

Enhanced marketability (or marketing benefits)	Between Groups	8.928	4	2.232	2.165	**0.073**
	Within Groups	282.427	274	1.031		
	Total	291.355	278			
High return on investment	Between Groups	13.186	4	3.296	4.115	0.003
	Within Groups	220.3	275	0.801		
	Total	233.486	279			
Better workplace environment	Between Groups	14.768	4	3.692	6.156	0.000
	Within Groups	164.943	275	0.6		
	Total	179.711	279			
Thermal comfort (better indoor temperature)	Between Groups	23.063	4	5.766	7.986	0.000
	Within Groups	197.11	273	0.722		
	Total	220.173	277			
Better rental income and increased lettable space	Between Groups	8.447	4	2.112	2.296	**0.059**
	Within Groups	252.924	275	0.92		
	Total	261.371	279			
Attract premium clients and increased property values	Between Groups	25.007	4	6.252	6.681	0.000
	Within Groups	257.336	275	0.936		
	Total	282.343	279			
Reduced construction and demolishing wastes	Between Groups	20.827	4	5.207	6.167	0.000
	Within Groups	232.169	275	0.844		
	Total	252.996	279			
Preservation of natural resources and non-renewable fuels/energy sources	Between Groups	28.17	4	7.043	9.452	0.000
	Within Groups	204.901	275	0.745		
	Total	233.071	279			
Sets standards for future design and construction	Between Groups	20.798	4	5.2	5.988	0.000
	Within Groups	238.77	275	0.868		
	Total	259.568	279			
Reduced use of construction materials (materials-efficiency)	Between Groups	16.043	4	4.011	3.672	0.006
	Within Groups	298.202	273	1.092		
	Total	314.245	277			
Attracting quality employees and reduced employee turnover	Between Groups	12.441	4	3.11	3.062	0.017
	Within Groups	278.333	274	1.016		
	Total	290.774	278			
Corporate social responsibility	Between Groups	19.831	4	4.958	5.509	0.000
	Within Groups	246.585	274	0.9		
	Total	266.416	278			
Facilitating a culture of best practice sharing	Between Groups	7.802	4	1.951	2.085	**0.083**
	Within Groups	257.308	275	0.936		
	Total	265.111	279			
Efficiency in construction process and management practices	Between Groups	7.862	4	1.965	2.146	**0.075**
	Within Groups	251.838	275	0.916		
	Total	259.7	279			
Improved performance of national economy and job creation	Between Groups	10.632	4	2.658	2.862	0.024
	Within Groups	252.639	272	0.929		
	Total	263.271	276			

With those showing significant difference in ratings of drivers of adopting green building concepts and technologies among professional background, multiple comparison was used to assess the type of professionals with different views on these drivers of green building. The variations in the level of agreement among the various professionals on the drivers of GBCTs adoption is as follows;

Driver: Reduced Lifecycle Costs

- Architects rated this significantly higher than:
  - Engineers
  - Project/Construction Managers
- Quantity Surveyors also rated it higher than:
  - Project/Construction Managers

Driver: Greater Energy-efficiency of Buildings

- Architects rated this significantly higher than:
  - Engineers
  - Project/Construction Managers and other professionals
- Project/Construction Managers and other professionals also rated it higher than:
  - Engineers
  - Quantity Surveyors

Driver: Greater Water-efficiency of Buildings

- Architects rated this significantly higher than:
  - Quantity Surveyors
  - Engineers
- Project/Construction Managers and other professionals also rated it higher than:
  - Engineers

Driver: Enhanced Occupants' Health and Comfort and Satisfaction

- Architects rated this significantly higher than:
  - Quantity Surveyors
  - Engineers

Driver: Reduced Environmental Impacts of buildings

- Architects rated this significantly higher than:
  - Project/Construction Managers and other professionals
  - Engineers
- Project/Construction Managers and other professionals also rated it higher than:
  - Engineers

Driver: Reduced Use of Construction Materials (materials-efficiency)

- Architects rated this significantly higher than:
  - Quantity Surveyors
  - Engineers

Driver: Improved Performance of National Economy and Job Creation

- Quantity Surveyors rated this significantly higher than:
  - Architects
  - Engineers

Driver: Preservation of Natural Resources and Non-renewable

- Engineers rated this significantly higher than:
  - Quantity Surveyors

Architects' agreement level was significantly higher than quantity surveyors and engineers on the following drivers; increased overall staff productivity, better indoor environmental quality, good company image and reputation, better workplace environment, thermal comfort (better indoor temperature), attract premium clients and increased property values, reduced construction and demolishing wastes, sets standards for future design and construction, attracting quality employees and reduced employee turnover, and corporate social responsibility.

From the foregoing, it can be deduced that;

- Architects were generally more supportive of all major drivers, particularly health, comfort, and design-related drivers.
- Quantity Surveyors were more concerned with economic drivers like lifecycle cost and national job creation.

5. Discussion of important drivers of green building uptake

This section discusses the five most important drivers of GBCTs uptake in the GCI according to stakeholders ranking. These include; greater energy efficiency of buildings, enhanced occupant health and well-being, greater water efficiency, better indoor environmental quality and thermal comfort, and reduced environmental impacts.

5.1 Greater energy efficiency of buildings

Greater energy efficiency as a driver of GBCTs uptake was ranked first (MS=4.42, SD=0.83 and RII=88.4%) by respondents as the topmost driver propelling stakeholders to embrace GBCs. Several studies have reported the global building construction industry as a huge consumer of resources more especially energy (Low et al. 2012). As such, this finding is both unsurprising and very important. This has resulted in the prioritization of energy-saving measures by many stakeholders globally. This finding concurs with similar findings in previous studies. Windapo (2014) as an example reported in a study in South Africa that the key driver impelling stakeholders to incorporate GB principles in their projects is rising energy costs and that it has been persistent. Studies by both Ahn et al. (2013) and Mulligan et al. (2014) also affirmed energy conservation as the most important driver propelling the adoption of green building practices. Also echoing this finding is the international survey of experts on drivers for implementing GBTs by Darko, Chan, Owusu-Manu, et al. (2017) who established greater energy efficiency as a key driver influencing the implementation of GBTs globally. It therefore means greater energy efficiency as a key driver pertains to both developing and developed countries implying that higher energy costs is a global concern and is thus attracting stakeholders to implement green practices. Buildings consume energy in different ways; mostly used to light, cool or heat up (in cold climates). This study proposes the application of energy-efficient technologies that would help reduce the high energy consumption of buildings and the built environment. As an example, studies by United States Green Building Council (USGBC) (2003) reports a 20–50% savings of energy costs as achievable by the application of energy saving technologies, natural daylight and ventilation, renewable energy technologies, and light-reflective materials. Also, Yang and Yu (2015) report that, fluorescent lamps are capable of reducing the amount of energy needed for attaining the same level of illumination compared to when traditional incandescent lamps are used. They also report that solid-state lighting technology helps a building to use only 10% of the energy used by incandescent lamps for reaching the same level of illumination and lasting 10 times longer. Both Zhang et al. (2011) and Roufechaei et al. (2014) suggest the use of natural ventilation as an inexpensive energy saving option while studies by Love et al. (2012) established that, to make a gain in the reduction of building energy use, stakeholders may apply such technologies as solar panels (e.g. on roofs and facades), or wind turbines. The reduced energy consumption and hence cost savings from implementing GBTs can be an important economic benefit for the stakeholder throughout.

As far as Ghana is concerned, this is an expected finding given that, the country has experienced long periods of recurring energy crisis and *dumsor* (unstable power supply) over the years since 1984 with the latest occurring from 2013 till early 2017. Stakeholders therefore by this finding confirms the importance attached to energy efficiency as a driver of GB uptake in the construction industry in Ghana as the situation creates the demand for alternatives to improve. It is reported by the Energy Commission of Ghana (ECG) (2015) that, the residential sector in Ghana between 2005 and 2014 consumed 43% of the country's total energy thus being the highest consumer of energy than any other economic sector. This implies that, the success of greater energy-efficiency of buildings and the built environment by the application of energy-efficient technologies as suggested earlier would significantly contribute to solving the energy situation in the country. It would also spur on Ghana's many efforts at meeting the UN SDGs specifically Goal 7 – affordable and clean energy- ensure access to affordable, reliable sustainable and modern energy for all. This is achievable given that the recently launched Ghana Building codes has provisions for the application of energy-efficient technologies as part of the requirements for the grant of building permits.

5.2 Enhanced occupant health and well-being

This driver was ranked second (MS=4.36, SD=0.875 and RII=87.2%) by respondents in the survey in the Ghana construction industry implying that, it's the second topmost propelling force for the uptake of GBs in Ghana. According to the United States Environmental Protection Agency (USEPA) (2018), humans averagely are indoors for 90% of their time and in which case the number of pollutants is estimated to be 2-5 times higher than outdoors. As such, poor conditions indoors if allowed to exist affects people differently including poor concentration, respiratory ailments, increased staff absenteeism, reduced staff productivity, amongst others. It is for this reason, the USGBC (2003) advocates that, design features that boost indoor air quality are important and cost-effective strategies to enhance the productivity of employees. As such building technologies that would enhance and enable the attainment of better indoor air conditions has become attractive to construction professionals in Ghana which could be the reason for the high rank of this driver. This finding is consistent with studies by both Gou et al. (2014) and Dahiru et al. (2014) who both found enhanced occupant health and well-being as a top driver motivating stakeholders to adopt GB. Gou et al. (2014), in an occupant survey discovered the benefits of healthy, comfortable, and productive work environment by employees as one of the major reasons for the interest in GBs. It also reinforces the findings of Darko et al. (2017) and Darko, Chan, Owusu-Manu, et al. (2017) who both found enhanced occupant health and well-being as a top driver of GB adoption in Ghana and internationally. The finding however differs from Low et al. (2014) who found that it is the least important driver for GB.

5.3 Greater water efficiency

Greater water efficiency of buildings as a driver of GB uptake was the third most important driver (MS=4.34, SD=0.876 RII=86.8%) influencing the adoption of GB in Ghana. This finding is an affirmation of Darko, Chan, Owusu-Manu, et al. (2017) study regarding the drivers for implementing GBTs which found Greater water-efficiency of buildings to be the third most important driver too. This implies that efficient water use in buildings is an issue pertaining to both developed and developing countries which is motivating the uptake of GBCTs. Ghana as a developing country has had challenges with water delivery and successive governments have battled recurring water crisis over time. For instance, the latter parts of 2007 leading to February 2008 witnessed severe water shortages in Ghana and the popular 'Kufuor gallons' became synonymous with water scarcity and people had to carry these gallons and trek long distances in search of water, particularly, in Accra. Again, in January, 2018, the Ghana water company limited announced a water rationing time table as a result of inadequate supply due to the dry season (Nathan Gadugah, 2018). These experiences by stakeholders in Ghana may be the coercing forces to adopt water efficient technologies and measures to reduce water use in buildings. However, it is noted that the application of suitable GBTs such as rainwater harvesting, water reuse, greywater recycling, permeable surface technology and on-site sewage treatment, improve the water efficiency of buildings and thus impels the adoption of GBTs (Anzagira et al. 2019; Zhang et al. 2011). Interestingly, this finding differs from the study of Darko, Chan, Gyamfi, et al. (2017). Their study did not find greater water efficiency as an important driver in Ghana. This could possibly be the result of limiting their study to only 43 experts who might be elites and not exposed to the constraints of water shortages. Similarly, water-efficient technologies failed to make the top five green building technologies employed in buildings in the Ghana construction industry in the study by Anzagira et al. (2022). This could be attributed to the high upfront costs of these technologies and the low level of awareness according to the World Bank (2022). Danso et al. (2022) also affirms this finding noting that low-flow fixtures are present in urban markets but constitute less than 5% of total plumbing sales.

It is undeniable that economic benefits (lower water bills, and cost savings) accrue due to efficient and low water usage of buildings designed to be water-efficient. These thus benefits the end-user and also make up for the higher initial costs over the lifetime of the building. These encourage stakeholders to implement GBTs in the construction industry in Ghana.

5.4 Better indoor environmental quality and thermal comfort

The related drivers of better indoor environmental quality and thermal comfort (better indoor temperature) received the fourth position (MS=4.27, SD=0.849 and RII=85.4%) and the fifth position (MS=4.23, SD=0.884 and RII=83.8%)

respectively according to the respondents in this study. These two drivers are closely related in that, Indoor Environmental Quality (IEQ) encompasses the conditions inside a building; air quality, lighting, thermal conditions, ergonomics viz their effects on occupants or residents. As stated earlier, people in modern societies spend more than 90% of their time in indoor environments and as such indoor environmental quality in households has a significant impact on public health and well-being. IEQ is an important requirement that stakeholders developing GBs must satisfy in all the developed green building rating tools (e.g. LEED and Green Star) for which reason suitable GBTs are critical to achieve. Zhang, Platten, et al. (2011) and Zhang, Shen, et al. (2011) advocated natural ventilation, ample ventilation for pollutant and thermal control, and optimizing building envelope thermal performance as technologies that could be applied to achieve this. Stakeholders in Ghana ranking this driver as important for GB uptake is attributable to the temperature variations in the warm humid climate that pertains in Ghana. Better indoor environmental conditions are required to ensure the productivity and well-being of occupants. This finding echo similar findings by Ahn et al. (2013) who found improved indoor environmental quality highlights the significance of indoor environments that are related to the symptoms, health conditions, and well-being of building occupants. The USGBC (2003) supports this assertion that, GBs typically offer more satisfying and healthier work environments for occupants; thereby increasing personal wellbeing, reducing sick leaves and staff absenteeism, and increases commitment to the company that provides the building. These productivity gains resulting attract stakeholders to adopt GBCTs. The finding also concurs with Darko, Chan, Owusu-Manu, et al. (2017) who also found better indoor environmental quality to be a key driver of GB adoption noting that, when GBTs, such as efficient daylighting systems and solar shading devices are applied, better indoor environments can be achieved.

5.5 Reduced environmental impacts

The driver reduced environmental impacts, received the sixth position (MS=4.19, SD=0.874 and RII=83.8%) as a driver influencing stakeholders to adopt GB. The construction industry has gained notoriety for its negative weighty impacts on the environment including the consumption of resources and the emission of CO_2 gas. The concern for mitigation of these impacts may be responsible for stakeholders' rating for this driver. It is widely acknowledged in literature that GBs are energy-efficient, water and resource efficient and impacts lesser on the environmental (Low et al., 2012). This study finding concurs with similar studies that found that, environmental concern is an important driver influencing the uptake of GBs by stakeholders (Manoliadis et al. 2006; Love et al. 2012; Wang et al. 2014; Kumah et al. 2022). This finding is an affirmation of Darko, Chan, Owusu-Manu, et al. (2017) survey of international experts on drivers for implementing GBTs which found the reduction of environmental impacts of buildings to be the second most important factor propelling the adoption of GBTs. The finding however contrasts the study of Darko, Chan, Gyamfi, et al. (2017) whose study did not find it as an important driver to GB adoption in Ghana. In Ghana, reinforced concrete, sandcrete blocks, and mortar are the materials commonly used for the construction of the structural framework and for internal and external walls respectively of buildings. These together with the construction activities consumes high amounts of energy, water and admixtures bearing heavily on the environment. As such, the implementation of green practices is recommended to stakeholders in Ghana to mitigate these impacts with buildings that would be resource efficient and eventually a zero-carbon environment.

6. Conclusion and recommendation

The study examined the important drivers influencing the adoption of green building concepts and technologies. This objective was addressed by conducting a scoping review of germane literature on the drivers of GBCTs uptake in the construction industry. From this review,
23 drivers were adopted and developed into a questionnaire for GCI stakeholders' assessment in a survey. Descriptive analysis was then employed to compute the mean scores and RII with the aim of determining the most important green building drivers. The survey results revealed that the top five most important drivers propelling the uptake of GB in Ghana are: greater energy-efficiency of buildings (4.42); enhancement of occupants' health and comfort and satisfaction (4.36); greater water-efficiency of buildings (4.34); better indoor environmental quality (4.27), and thermal comfort, i.e. better indoor temperature (4.23). Also significantly rated were reduced environmental impacts of buildings (4.19) and better workplace environment (4.19). All mean scores exceeded the neutral midpoint of 3.0, indicating general agreement among respondents on the importance of all 23 drivers. Comparison of the views of the different professional groups among the stakeholders also revealed that, there were four drivers in which professionals had no significant difference in the mean scores, thus; enhanced marketability (or marketing benefits), better rental income and increased lettable space, facilitating a culture of best practice sharing, and efficiency in construction process and management practices, with p-values > 0.05.

The results from this study have significance aligned to industry practice and theory. In practical terms, stakeholders such as estate developers will have a clear understanding of the key drivers found including energy-efficiency of buildings, enhancement of occupants' health and comfort and satisfaction, and greater water-efficiency of buildings among others as identified and capitalize on them by ensuring they apply them in their projects. This will make them more attractive to clients enabling them to sell faster and yield better returns. Also, investors who are interested in investing in green building technologies (GBTs) will be guided by the findings of this study to make decisions to invest in the GBTs that promote the important drivers established by the study. Policy makers on the hand would benefit from the empirical evidence provided by the study as they will formulate and implement laws and policies that prioritises energy-efficiency, water-efficiency and other important GB drivers identified in the study according to stakeholder views.
Theoretically, the findings of this study contribute to the growing green building body of knowledge and adds to the pool of literature on GB drivers in developing countries since it is one of the few empirical studies on GB drivers that cuts across a broad spectrum of GCI stakeholders.

Based on the findings, the ensuing recommendations may help in achieving goals 12 and 13 of the SDGs by adopting the important drivers emanating from the study.

- GB requirements should become an integral part of the permitting regime by all MMDA's in Ghana. This regulatory integration would ensure that developers are held accountable for sustainability from the design phase onward. This would upscale uptake as developers would be conscious of the provisions.
- There is need to consider GB as an integral part of the construction process itself rather than something superfluous or extra that has been necessitated through mandatory regulations. To this end, the review of the curricula of construction related courses to include GB concepts would ensure all construction practitioners have some level of awareness and knowledge to facilitate the implementation.

Despite the significant implications of the study findings some limitations abound; the research type adopted is largely quantitative thus enabling the collection of the opinions of a wider section of stakeholders to determine the most important drivers for GBCTs uptake in Ghana. It however made it difficult to collect verbatim responses from stakeholders. Future research focusing on a qualitative study to acquire in-depth description and appreciation of GB practices as the industry matures over the time is thus recommended. The analytical tools employed (Mean Scores, RII, and ANOVA) in the study also made it not possible to establish the relationships between the GB drivers found. A future study using a more complex analytical tool such as the Partial Least Structural Equation Modelling (PL-SEM) to establish the relationships between the important drivers found in the study as well as their influences on GB adoption in the Ghana construction industry is recommended.

This study provides empirical evidence of stakeholder-driven priorities in green building adoption, offering guidance for sustainable construction practices and policies in Ghana.

References

Abidin, N.Z. and Powmya, A. (2014). Perceptions on motivating factors and future prospects of green construction in Oman. *Journal of Sustainable Development,* 7 (5): 231.

Agyekum, K., Goodier, C. and Oppong, J. A. (2022), Key drivers for green building project financing in Ghana, Engineering, Construction and Architectural Management, 29 (8):3023-3050. https://doi.org/10.1108/ECAM-02-2021-0131

Agyekum, K., Adinyira, E. and Ampratwum, G. (2020). Factors driving the adoption of green certification of buildings in Ghana. Smart and Sustainable Built Environment, 9 (4):595-613. https://doi.org/10.1108/SASBE-02-2019-0017

Ahn, Y. H., Pearce, A. R., Wang, Y. and 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. https://doi.org/10.1080/2093761X.2012.759887.

Aktas, B. and Ozorhon, B. (2015). Green Building Certification Process of Existing Buildings in Developing Countries: Cases from Turkey. *Journal of Management in Engineering,* 31 (6). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000358.

Alsanad, S., Gale, A. and Edwards, R. (2011). Challenges of sustainable construction in Kuwait: Investigating level of awareness of Kuwait stakeholders. *World Academy of Science, Engineering and Technology,* (59): 2197-2204.

Amoah, P., Ahadzie, D.K, and Danso, A. (2011). The Factors affecting construction performance in Ghana. The perspective of small-scale building contractors: *Ghana Institution of Surveyors Journal, The Ghana Surveyor,* 4 (1): 41-48.

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, e00191. https://doi.org/10.1016/j.sciaf.2019.e00191

Anzagira, L.F., Duah, D., Badu, E., Simpeh, E.K., Amos-Abanyie, S. and Marful, A. (2022). Application of green building concepts and technologies for sustainable building development in Sub-Saharan Africa: the case of Ghana, Open House International, 47 (3): 408-427. https://doi.org/10.1108/OHI-02-2022-0054

Augenbroe, G.L.M. and Pearce, A.R. (2009). Sustainable Construction in the USA: A perspective to the year 2010. In Construction Industry: Changing Paradigm, Edited by: Pain, A.K. Hyderabad, India: The Icfai University Press.

Balaras, C. A., Gaglia, A, G., Georgopoulou, E., Mirasgedis, S., Sarafidis, Y. and Lalas, D.

P. (2007). European residential buildings and empirical assessment of the Hellenic building stock, energy consumption, emissions and potential energy savings. *Building and Environment* 42 (3): 1298-1314.

Bond, S. (2010). Lessons from the leaders of green designed commercial buildings in Australia. *Pacific Rim Property Research Journal,* 16 (3): 314-338.

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

Chan, A. P. C., Darko, A., Olanipekun, A. O. and 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. https://doi.org/10.1016/j.jclepro.2017.10.235.

Creative Research Systems (2003). The survey system.

http://www.surveysystem.com/scalc.htm (accessed October 21, 2018)

Czaja, R. and Blair, J. (1996). Designing surveys: a guide to decisions and procedures. Thousand Oaks, California; London, Pine Forge Press.

Danso, S. Y., Drechsel, P., & Aidoo, R. (2022). Market potential for water-efficient plumbing in urban Ghana. *Journal of Water Sanitation and Hygiene for Development,* 12(3), 456-470. https://doi.org/10.2166/washdev.2022.125

Darko, A., Chan, A. P. C., Gyamfi, S., Olanipekun, A. O., He, B. J. and Yu, Y. (2017). Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective. *Building and Environment,* 125: 206–215.

https://doi.org/10.1016/j.buildenv.2017.08.053.

Darko, A., Chan, A. P. C., Owusu-Manu, D. G. and Ameyaw, E. E. (2017). Drivers for implementing green building technologies: An international survey of experts. *Journal of Cleaner Production,* 145: 386–394. https://doi.org/10.1016/j.jclepro.2017.01.043.

Darko, A., Ping, A., Chan, C., Yang, Y., Shan, M. and He, B. (2018). Influences of barriers, drivers, and promotion strategies on green building technologies adoption in developing countries: The Ghanaian case. *Journal of Cleaner Production,* 200: 687– 703. https://doi.org/10.1016/j.jclepro.2018.07.318.

Darko, A., Zhang, C. and Chan, A. P. C. (2017). Drivers for green building: A review of empirical studies. *Habitat International*, 60: 34–49.
https://doi.org/10.1016/j.habitatint.2016.12.007.

Devine, A., and Kok, N. (2015). Green certification and building performance: implications for tangibles and intangibles. *Journal of Portfolio Management.* 41 (6): 151-163.

Djokoto, S. D., Dadzie, J., & Ohemeng-ababio, E. (2014). Barriers to Sustainable Construction in the Ghanaian Construction Industry: Consultants Perspectives. *Journal of Sustainable Development,* 7 (1): 134–143. https://doi.org/10.5539/jsd.v7n1p134.

Edwards, B. (2006). Benefits of green offices in the UK: Analysis from examples built
in the 1990s. *Sustainable Development*, 14 (3): 190-204. https://doi.org/10.1002/sd.263

Energy Commission of Ghana, (2006). Strategic national energy plan, Energy Commission, Ghana.

Eybpoosh, M., Dikmen, I. and Birgonul, M., (2011). Identification of Risk Paths in International Construction Projects Using Structural Equation Modeling. *Journal of Construction Engineering and Management,* 137 (12): 1164-1175. Doi: 10.1061/(ASCE)CO.1943-7862.0000382.

Falkenbach, H., Lindholm, A. L. and Schleich, H. (2010). Environmental sustainability: Drivers for the real estate investor. *Journal of Real Estate Literature,* 18 (2): 203-223.

Gou, Z., Prasad, D., and Siu-Yu, L. S. (2013). Are green buildings more satisfactory and comfortable? *Habitat International,* 39: 156–161. http://doi.org/10.1016/j.habitatint.2012.12.007

Hwang, B.G., Shan, M., Xie, S., and Chi, S. (2017). Investigating residents' perceptions of green retrofit program in mature residential estates: the case of Singapore. *Habitat International,* 63: 103-112.

Kats, G. (2003). Green Building Costs and Financial Benefits. Westborough, MA: Massachusetts Technology Collaborative, Boston.

Kats, G. (2013). Greening our built world: costs, benefits, and strategies. Island Press.

Kumah, V.M.A., Agyekum, K., Botchway, E.A., Pittri, H., and Danso, F.O. (2022). Examining Built Environment Professionals' Willingness to Pay for Green Buildings in Ghana. *Buildings*, 12: 2097. https://doi.org/10.3390/buildings12122097

Li, X., Strezov, V., and Amati, M. (2013). A qualitative study of motivation and influences for academic green building developments in Australian universities. *Journal of Green Building,* 8 (3): 166-183.

Love, P.E., Niedzweicki, M., Bullen, P.A., and Edwards, D.J. (2012). Achieving the green building council of Australia's world leadership rating in an office building in Perth. *Journal of Construction Engineering and Management,* 138 (5): 652-660.

Low, S. P., Gao, S., and Tay, W. L. (2014). Comparative study of project management and critical success factors of greening new and existing buildings in Singapore. *Structural Survey*, 32 (5): 413-433.

Luo, W., Kanzaki, M. and Matsushita, K. (2017). Promoting green buildings: do Chinese consumers care about green building enhancements? *International Journal of Consumer Studies.* http://dx.doi.org/10.1111/ijcs.12364.

Manoliadis, O., Tsolas, I., and Nakou, A. (2006). Sustainable construction and drivers of change in Greece: A Delphi study Sustainable construction and drivers of change in Greece: A Delphi study. *Construction Management and Economics,* 24 (2): 113–120. https://doi.org/10.1080/01446190500204804.

Mondor, C., Hockley, S., and Deal, D., (2013). The David Lawrence convention center: how green building design and operations can save money, drive local economic opportunity, and transform an industry. *Journal of Green Building,* 8 (1): 28-43.

Mulligan, T. D., Mollaoglu-Korkmaz, S., Cotner, R., and Goldsberry, D. A. (2014). Public Policy and Impacts on Adoption of Sustainable Built Environments: Learning from the Construction Industry Playmakers. *Journal of Green Building*, 9 (2): 182–202.

Nani, G. (2009). Conceptual framework for developing a standard method of measurement of building construction works for Ghana, Ph.D. dissertation Kwame Nkrumah University of Science and Technology, Kumasi.

Nathan Gadugah (29-01-2018), Water shortage: GWCL to publish water rationing timetable. [https://www.myjoyonline.com/news/2018/january-29th/water-shortage-gwcl-to-publish-water-rationing-timetable.php] (Accessed 12-06-2018).

Ofori-Kuragu, J.K, B.K. Baiden, and E. Badu (2016). Key performance indicators for project success in Ghanaian contractors, *International Journal of Construction Engineering Management,* 5 (1): 1-10.

Oyedele, L. O. (2013). Analysis of architects' demotivating factors in design firms.
International Journal of Project Management, 31 (3): 342-354. https://doi.org/10.1016/j.ijproman.2012.11.009

Park, J. S., and Yoon, C. H. (2011). The effects of outdoor air supply rate on work performance during 8-h work period. *Indoor Air*, 21 (4): 284–290. doi:10.1111/j.1600-0668.2010.00700.x

Periyannan, E., Ramachandra, T., and Geekiyanage, D. (2023). Assessment of costs and benefits of green retrofit technologies: Case study of hotel buildings in Sri Lanka. *Journal of Building Engineering*, 78. ISSN 2352-7102, https://doi.org/10.1016/j.jobe.2023.107631.

Qi, G. Y., Shen, L. Y., Zeng, S. X., and Jorge, O. J. (2010). The drivers for contractors' green innovation: An industry perspective. *Journal of Cleaner Production*, 18 (14): 1358–1365.

Roufechaei, K. M., Bakar, A. H. A., and Tabassi, A. A. (2014). Energy-efficient design for sustainable housing development. *Journal of Cleaner Production*, 65: 380–388.

Rowley, J. (2014). Designing and using research questionnaires. *Management Research Review*, 37 (3). DOI: 10.1108/MRR-02-2013-0027.

Serpell, A., Kort, J., and Vera, S. (2013). Awareness, actions, drivers and barriers of sustainable construction in Chile. *Technological and Economic Development of Economy*, 19 (2): 272–288. https://doi.org/10.3846/20294913.2013.798597.

Son, H., Kim, C., Chong, W. K., and Chou, J. S. (2011). Implementing sustainable development in the construction industry: constructors' perspectives in the US and Korea. *Sustainable Development,* 19 (5): 337-347.

Simpeh, E.K. and Smallwood, J.J. (2020). An integrated model for predicting the probability of adoption of green building in South Africa. *Journal of Engineering, Design and Technology,* 18 (6): 1927-1950. doi: 10.1108/JEDT-09-2019-0244.

Thatcher, A. & Milner, K. (2016). Is a green building really better for building occupants? A longitudinal evaluation. *Building and Environment*, 108:. 194-206. https://doi.org/10.1016/j.buildenv.2016.08.036

Tran Q, Nazir S, Nguyen T-H, Ho N-K, Dinh T-H, Nguyen V-P, Nguyen M-H, Phan Q-K, Kieu T-S (2020). Empirical Examination of Factors Influencing the Adoption of Green Building Technologies: The Perspective of Construction Developers in Developing Economies. *Sustainability*. 12(19):8067. https://doi.org/10.3390/su12198067

UNEP (2007). Buildings and Climate Change: Status, Challenges and Opportunities. United Nation environment programme. [Online] Available from http://www.unep.fr/shared/publications/pdf/DTIx0916xPA-BuildingsClimate.pdf [Accessed: 19 March 2017].

UNEP (2009). Buildings and Climate Change, Sustainable United Nations, UNEP Sustainable Buildings and Climate Initiative (SBCI), Milan.

USGBC, (2003). Building momentum: National trends and prospects for high performance green buildings. Washington, DC: Author.

Wang, Z., Zhang, B., and Li, G. (2014). Determinants of energy-saving behavioral intention among residents in Beijing: Extending the theory of planned behavior. *Journal of Renewable and Sustainable Energy*, 6 (5): 1–18. https://doi.org/10.1063/1.4898363.

Windapo, A. O. (2014). Examination of Green Building Drivers in the South African Construction Industry: Economics versus Ecology. *Sustainability,* 6: 6088–6106. https://doi.org/10.3390/su6096088.

Wong, J. K. W., Chan, J. K. S., and Wadu, M. J. (2016). Facilitating effective green procurement in construction projects: An empirical study of the enablers. *Journal of Cleaner Production,* 135: 859-871.

World Bank. (2022). Ghana - Water security and efficiency diagnostic report. World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099735303072321903/P17425200d117007309770a7a71b3e52e5e [Accessed: 9 July 2025].

Wu, P., and Low, S.P. (2010). Project management and green buildings: lessons from the rating systems. *Journal of Professional Issues in Engineering Education and Practice*, 136 (2): 64-70.

Yang, M., and Yu, X. (2015). Energy-Efficient Technologies. In Energy Efficiency, Green Energy and Technology (pp. 113-126), doi: 10.1007/978-1-4471-6666-5_10. Springer-Verlag, London.

Zhang, X., Platten, A., and Shen, L. (2011)., Green property development practice in China: Costs and barriers. *Building and Environment,* 46 (11): 2153-2160.

Zhang, X., Shen, L., and Wu, Y. (2011). Green strategy for gaining competitive advantage in housing development: A China study. *Journal of Cleaner Production,* 19 (2–3): 157–167. https://doi.org/10.1016/j.jclepro.2010.08.005.

Zuo, J., Pullen, S., Palmer, J., Bennetts, H., Chileshe, N., and Ma, T. (2015). Impacts of heat waves and corresponding measures: a review. *Journal of Cleaner Production,* 92: 1-12.