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Promoting Climate Resilience in Building Construction Industry in Ghana

Chrysogonus Asante Frimpong

c/o Kumasi Metropolitan Assembly (KMA) (Department of Works)

Nhyiaeso Sub-Metro, P.O BOX 1916, Kumasi-Ghana

E-mail: Chrysogonus17@gmail.com

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Abstract

This study reports the perspectives of building construction stakeholders on how they are promoting climate resilience. Using descriptive research design with a purposive sampling through online questionnaire and adapted version of Relative Importance Index (RII) on selected environmental benchmarks, the major findings are: a) there is more to be done to promote green construction; b) many stakeholders still hold on to carbon-intensive approach; c) underlying cause for this lack of migration to less carbon use appears to be attitudinal than complete lack of knowledge of climate mitigation; d) many construction firms lack internal management system to monitor climate mitigation benchmarks indices. Based on these findings, recommendation being made is that construction managers may need to link up with international conferences to enhance professional competencies in advanced technologies for mitigating building-related carbon emission, while Government offers subsidies and green construction certification to promote contractors' awareness of climate resilience in building construction.

Keywords: Climate resilience; climate change mitigation; building construction; construction managers

1. Introduction

Greenhouse gases also known as GHGs are gases found in the atmosphere of the planet earth that trap heat. When the sun shines through the earth during the day, it warms the surface of the earth. During the night, when the surface becomes cool, the heat trapped during the day is released back into the air, but some of the heat is trapped by the greenhouse gases in the atmosphere. Overwhelming majority of green gas are carbon dioxide (CO2) emissions, with smaller amounts being methane (CH4) and nitrous oxide (N_20), which are also emitted. Global indicators show that a little more than 30% of the final energy consumption and 26% of global energy related emissions (8% being direct emissions from the production of electricity and heat used in buildings) is concentrated in the construction industry (Chiara et al., 2022). Whether in the developed or developing economies, this translates into about one out of every three global greenhouse gas emissions. Some two decades ago, Levin et al (2007) made the submission that the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) reported, that some 8.6 million metric tons of CO_2 were the outcome of building-related emissions. Between 1971 through to 2004, carbon emissions as a result of electricity used in buildings grew at a rate of 2.5% annually in respect of commercial buildings, and 1.7% for commercial buildings (Levine et al., 2007). Additionally, it is also on record, that some non-carbon dioxide emissions such as halocarbons, Chlorofluorocarbons (CFS) and hydrofluorocarbons (HFC's) emissions come from the construction and building sector because of their applications in the areas of cooling and refrigeration as well as for insulations.

The current estimate is that buildings alone contribute to about a third of the emissions of green gas during the construction phase. Efforts made in the past to resolve this, have had mixed record of success, notwithstanding the many carefully and well-funded polices that is capable of achieving significant results. Since the Copenhagen International Agreement in 2009, there has been a tremendous opportunity to make emissions from buildings become essential part of the global strategy to mitigate climate change impacts (https://www.c2es.org/content/cop-15-copenhagen/). This is because in all phases of construction, right from its initial on-site work and through its period of actual construction, (even though this period is relatively shorter) as well as its finishing, all these have significate impact on the environment. Construction obviously has potential contribution for economic and social development, promoting quality of life and enhancing a high standard of living, etc., yet it also has debilitating effect on the environment (Azqueta, 1992).

Indeed, the building industry has been seen to hold a significant potential for promoting a cost-effective GHG emission reduction. In 2022, at a UN Biodiversity Conference in Montreal, Canada, referred to as COP 15, six (6) key messages and four (4) priority areas were identified as crucial in the building sector to reduce GHG emissions related to building construction. Construction Design and Management (CDM) regulations which came into effect in 2015, have to do with regulations governing how building constructions are planned for example, in the UK, and it is aimed at promoting health, safety and welfare of construction workers. At the Montreal Conference, a reform of this 2015 CDM was recommended, so that it could also support especially in developing countries, the investment in energy efficient programmes (UNEP, 2009). The building sector, therefore, has been identified as a key area in the climate change debate. In terms of environmental impact of the construction industry, it is also estimated that in Ghana, while construction consumes some 40% of energy generally, resource consumption such as water, electricity and fuel were ranked within the leading first ten environmental impact of construction activities in Ghana. Construction therefore is among the leading exploiters of both renewable as well as non-renewable natural resources (Spence &Mulligan, 1995; Curwell & Cooper, 1998; Uher, 1999). As construction extracts natural resources, it simultaneously causes irreversible damage to the ecosystem, especially in the countryside and coastal areas (Curwell & Cooper, 1998; Ofori & Chan, 1998; Langford et al., 1999)

2. Statement of Problem

Many cities in the world have ambitious strategies to minimize emissions and increase climate resilience to protect communities and future extreme weather (www.c40knowdlegedhub.org). For the last two decades, empirical studies in Ghana suggest that, unrestrained reliance on fossil fuel as means of energy generation, has significantly precipitated environmental and social problems causing depletion of the Ozone layer, as well as the depletion of non-renewable resources (Simon et al., 2018). CO_2 emissions in Ghana in 2000 was 44 percent of the overall greenhouse emissions (Solomon et al., 2015). World Bank Report on Ghana in 2011, identified three main sectors as being responsible for Ghana's CO_2 emissions, namely: a) electricity and heat generation; b) transport sector; c) manufacturing industry, as well as the construction sector, be it residential, public and commercial (cf. Adu-Kumi, 2012). The construction industry in Ghana accounts for more than 15 percent of the nation's GDP, which translates into about US$ 8 billion of the last couple of years and it is projected to grow. Therefore, it offers employment to some 420,000 people with approximately 2,500 building and construction engineers in the market (cf. Department of Commerce, U.S.A, International Trade Administration, Ghana- Construction and Infrastructure, https://www.trade.gov/country-commercial-guides/ghana-construction -and- infrastructure)

Even though, construction industry contributes significantly to Ghana's economy, its negative impact on the environment has received very little attention (Amatepeh & Ansah, 2015). In spite of the social and economic gains, construction activities extend beyond the erection of houses, hospitals, schools, offices. It includes other civil engineering works as roads, bridges and communication infrastructure which boost the economy. However, in responding to all these, the Ghanaian construction industry exerts enormous pressures on biodiversity/ecosystem. The pressure on the ecosystem comes out glaringly especially when the depletion of the resources is hardly renewable. This could also affect, for example, land and water resources that support agriculture, which is the backbone of Ghana's economy and food security and their related impact on the vulnerable who depend on land for their survival (Dadzie & Dzokoto, 2013). Given that building construction continues to go up as a middle-income country, with increase in population in the last ten years in Ghana, and the fact that the impact of construction on the environment has received little attention, this paper intends to bridge the gap and to contribute to the literature.

3. Research Questions

1) What is the level of construction workers knowledge on GHG construction-related emissions?
2) What elements could be adopted by the construction industry to reduce carbon emissions more effectively?
3) What management systems should the government put in place to mitigate carbon emission and promote climate resiliency?

4. Theoretical Foundations/Literature Review

4.1 Strategies for Carbon Emission Reduction

Scholars have conducted studies on carbon emissions in the construction industry consequent upon contractors in the life cycle of construction. For example, a simulation approach strategy has been suggested as effective strategy to control greenhouse emissions (Tang et al. 2013). These authors showed that effective selection of strategies could both mitigate emissions without necessarily augmenting cost or delaying projects. Based on this reason, promoting construction contractors *Carbon Emissions Reduction Intention* (CERI) is of great value. Many scholars have consequently focused on practical ways to achieve reduction in carbon emissions in practical contexts. It is in this context that Chan et al (2022), make the submission that the use of low carbon materials during construction is capable of reducing energy consumption in buildings in their life cycle. Additionally, these authors also make the thesis that, the major obstruction for professionals to use low-carbon materials has to do with the need for more information on material performance. Some other researchers as Nässén et al (2007), examined carbon di oxide emissions during the construction phase, taking into consideration building materials, transportation, construction and machine production. While Yan et al (2010) studied the four sources of construction greenhouse emissions, which included manufacturing and transportation of building materials, energy consumption of construction equipment, energy consumption for resource handling, and disposal of construction waste, Wong (2013) used the European Construction Research and Development Organization tool to assess carbon reduction strategies of Australian contractors. Based on all these sources, the conclusion could be made that carbon emissions from construction could be mitigated and is doable by implementing these varied measures: a) using energy-saving materials and equipment, b) adopting efficient building designs and construction methods, c) enhancing monitoring and management of building energy consumption

4.2. Factors Affecting Carbon Emission Reduction

Studies have also focused on carbon reduction behaviour, as well as managers willingness and decision-making to reduce carbon emission. Mahmoud et al (2017) developed objective optimization model which identified some 134 key decision variables for a solution, on how to balance low cost and sustainable development performance for building stakeholders. In the same vein, Lam et al., (2010), worked on factors that could influence green construction specifications which included such benchmarks as: a) developing green technologies, b) ensuring specifications quality and reliability, c) leadership and responsibility allocation, d) stakeholder involvement, and e) improving evaluation benchmarks. Li and collaborators (2019), examined the impact of Project Environmental Practices from a lifecycle perspective, with a focus on the link between green design, green procurement, green construction, investment recovery on one hand, and their impact both ecological and organizational performance on the other. Their focus was on engineering factors that impacted on how building's structure could reduce carbon emissions. These engineering factors, therefore were not investigated from the point of view of the implementers such as contractors. This study rather anchored on *Technical Project Documentation* (TPD) which points out those factors that influence contractors CERI.

4.3 Theory of Planned Behavior (TPB).

This theory posits three things: a) that *behavioral intentions (BI)* and actual behvaiour are determined by three constructs; b) These three constructs are i) *attitude toward the behavior attitude (BA), ii) subjective norms (SN), and perceived behavioral control (PBC)* (Ajzen, 1991)

BA towards the behavior is a person's favorable or unfavorable evaluation or degree of assessing the behavior. If individuals are of the view that actions' they undertake benefit the environment, they are more likely to be committed to act friendly to the environment. On the other hand, if individuals see their behavior will be of harm to the environment, they will be less willing to act environmentally friendly. The SN is the influence of external social factors on person's behavior such as the social expectations, accepted values and norms. All things being equal, individuals will be more likely to adopt behaviors if the behvaiour so aligns with the expected social norms and expectations. PBC is how the individual perceives the ease or difficulty performing the behavior of interest. If individual perceives that being involved in environmentally friendly ways is easy that individual is more likely to take such course of actions. This construct has become topical theory to understand, predict and change behaviors in many disciplines, such as tourism, advertising, environmental management, and project management (Kim e; Zhenf t al., 2013; Gao et al., 2017; Zheng et al., 2018). In environmental psychology, this theory has been used to predict and promote behaviors that are pro-environmental (Si et al., 2019; Li et al., 2019; Jean et al., 2020). For example, Yuan (2018) studied the predicting factors of project managers wishes to reduce waste based on TPB. Result showed BA was the strongest predictor

4.4 Summary of Literature/Present Study

The above selected literature focusses on high carbon emissions of the construction industry vis-a-vis the global projection towards zero carbon emissions by 2050. To understand the factors affecting construction workers predisposition to reduce carbon emissions, selected thematic areas in the literature were examined above. This present study is based on the carbon reduction strategy as well as the factors that affect carbon emission, incorporating some of the constructs of the *Theory of Planed Behaviour* to investigate stakeholders' perspectives along three research questions: a) to find out the level of construction workers knowledge on carbon emission strategies; b) to examine factors affecting carbon emission reduction from construction workers perspectives and c) What management system has been established in construction firms to monitor the reduction of carbon dioxide emissions.?

5. Methodology

5.1 Research Design and Sample

This study was conducted in the Kumasi Metropolis, the second most densely populated city in Ghana. It has a current population of 3,768,000 (2023) which is about 4 percent increase from the 2022 population census. In terms of research design, the study used the descriptive research survey with online questionnaire and an adapted version of Relative Importance Index (RII)- an instrument usually used by environmentalists to measure environmental concerns as data collection instruments .These two instruments were used to gauge the perspectives of forty respondents in the building construction industry: Twelve (12) civil Structural Engineers, twenty-two (22) Private contractors and six (6) architects, making a total of forty (40) respondents. These respondents were purposively sampled. About 15% (constituting 6 people) were between the ages of 25-35yrs. 77.5% (constituting 31 people) were within the age group of 35-45yrs. The remaining 7.5% (constituting 3 people) were within the ages of 45-65yrs. The questionnaire solicited information on the first two research questions, namely: a) the level of construction workers knowledge on GHG construction-related emissions and b) factors affecting carbon emission reduction strategy from construction workers. To gauge respondents' perspectives on the research questions and selected climate resilience issues, interviews through open-ended questions were conducted. Scoring was done according to this range: *High (H) (0.8≤RI≤1); High-Medium (H-M) (0.6≤RI<0.8); Medium (M) (0.4≤RI<0.6); Medium-Low (M-L) (0.2≤RI<0.4) Low (L) (0≤RI<0.2).*

Demographic Data of Respondents

Table 1. Demographics of study participants

	Number	%
Gender		
Male	35	80
Female	5	20
Total	40	100
Age Group		
25 – 35	6	15
35 – 45	31	77.5
45 – 65	3	7.5
Years in the construction industry		
5 – 10	11	27.5
10 – 15	29	72.5
Sector of Employment		
Private	24	60
Government	16	40

Table 2. Sample Details: Categories of Respondents

Respondents	Number of Respondents		Percentages of Responses
Structural Engineers	12		30%
	Male = 10	Female = 2	
Private contractors	22		55%
	Male = 22	Female = 0	
Architects	6		15%
	Male = 3	Female = 3	
Total	**40**		**100%**

5.2 Data Analysis of Relative Importance Index

The relative value of each variable perceived by the respondents was expressed by the relative importance index (RII: Chan,2012). The RII is one of the most reliable methods for rating variables using a stretchered questionnaire. The RII approach has been used in previous studies to rank construction related environmental impacts (Ametepey & Ansah, 2015; Enshassi et al., 2015; Ijigah et al., 2013; JaiSai et al., 2022; Makwana et al., 2016) The RII is calculated using the following equation:

$$\text{Relative Importance Index (RII)} = \frac{\sum \omega}{A*N}$$

Where ω is the weighting given to each factor by the respondent (ranging from 1 to 5 in this study), A is the highest weight (which is 5 in this study), and N is the total number of respondents (which is 40 in this study). The relative importance index ranges from 0 to 1, with the highest RII indicating the maximum impact on the environment from construction-related activities. RII values were ranged into five levels: High (H) ($0.8 \leq RI \leq 1$), High – Medium (H-M) ($0.6 \leq RI < 0.8$), Medium (M) ($0.4 \leq RI < 0.6$), Medium – Low(M-L) ($0.2 \leq RI < 0.4$), and Low(L) ($0 \leq RI < 0.2$).

6. Results

6.1 Research Question 1: Level of Construction Workers Knowledge on GHG Construction-related Emissions

Respondents were almost all aware of GHG construction-related emissions and demonstrated a high knowledge. Three benchmarks were examined in this first part of the questionnaire to assess knowledge of construction-related consumptions and emissions: a) *resource consumption* which included raw material consumption, water consumption, electricity and fuel; b) *local issues at the construction site,* such as noise and vibration generation, generation of dust from machines, attention to landscape and c) *construction effects on biodiversity* such as vegetation removal, ecosystem interference, potential soil erosion, interception of water bodies. All the scoring was done according to this range *High (H) (0.8≤RI≤1); High-Medium (H-M) (0.6≤RI<0.8); Medium (M) (0.4≤RI<0.6); Medium-Low (M-L) (0.2≤RI<0.4) Low (L) (0≤RI<0.2).*

6.1.2 Resource Consumption

Environmental impacts under resource consumption were associated with high Relative index (RI) values. Raw material extraction was ranked the highest with a Relative index (RI) value scoring of High (H) (*0.8≤RI≤1*). Interviews with procurement personals also further validated these values stating that materials such as stones, Gravel, sand and wood were highly dependent upon during most construction projects. Water and fuel consumption which are all under the resource consumption also obtained scoring of (H) (*0.8≤RI≤1*) with only electricity consumption being ranked High-Medium (H-M) *(0.6≤RI<0.8).*

6.1.3 Local issues at Construction Site

Dust and noise generation which fall under local issues were also ranked within the High-Medium
(H-M) *(0.6≤RI<0.8)* with Relative Index (RI) values of 0.65 and 0.74 respectively.

6.1.4 Construction and biodiversity

There has always been links between construction and biodiversity and three main indicators came to the fore, such as product production, construction process and whether or not habitat is retained or not especially with respect to common species. With respect to the question on interference with the ecosystem, Vegetation removal was ranked the second highest overall with a Relative Index (RI) value of 0.85 which falls with High (H) (*0.8≤RI≤1)* on the scoring sheet. This was followed by interference with the ecosystem regarding the loss of habitats for species which scored a Relative Index (RI) value of 0.81 which falls within High (H) (*0.8≤RI≤1).* Interception of waterbodies was found to be the lowest amongst the biodiversity impacts scoring a Relative Index (RI) value of 0.59 which lies with the range of Medium (M) (*0.4≤RI<0.6).*

6.2 Research Question 2: What elements could be adopted by the construction industry to reduce carbon emissions more effectively?

Based on responses to this second research question, it could be inferred that on the whole, respondents were of the view that specific elements that could be adopted to reduce carbon emissions drastically in the construction industry included the following: 1) The local sourcing of construction materials could drastically reduce carbon emissions as a result of transportation. 2) harvesting and using rain water during the construction stage to reduce amount of water pumped into construction which respondents perceived was equally heavily dependent on energy; 3) adopting systems such as high efficiency toilets (HETs) and high efficiency urinals (HEUs) in construction sites; 4) re-use and renovation of standing structures rather than tearing them down. Using the Relative Importance Index to scale respondents' responses, the re-use and renovation of standing structures, rather than tearing them up completely was scored Medium – Low(M-L) (0.2 ≤ RI < 0.4l by more than half of respondents (62.5%, constituting

25 respondents) suggesting that more than 25 respondents appeared not to favour this approach , while the rest 8 and 7 respondents scored it between High (H) (0.8 ≤ RI < 1),), High – Medium (H-M) (0.6 ≤ RI < 0.8, respectively.

This suggested that this was not usually factored into construction planning by many construction managers in Ghana. The second element that was also equally scored medium (Medium (M) (0.4 ≤ RI < 0.6) by 50 % of respondents and High – Medium (H-M) (0.6 ≤ RI < 0.8, by another 50% respectively, was the need to sourcing local construction materials to reduce carbon emission. Harvesting and using rain water during the construction stage to reduce amount of water pumped into construction equally dependent on energy and adopting systems such as high efficiency toilets (HETs) and high efficiency urinals (HEUs) in construction sites, scored High – Medium (H-M) (0.6 ≤ RI < 0.8, (10%), Medium (M) (0.4 ≤ RI < 0.6) (5%), Medium – Low(M-L) (0.2 ≤ RI < 0.4) (25%) respectively. Construction workers admittedly stated that their knowledge on materials that could be used in place of the existing carbon intensive materials was very low. This explained the low scoring. In summary, the factors affecting carbon emission reduction as per the views of respondents in this study were found to be mostly: 1) attitude of non-reuse and non-renovation typical with older engineers and construction managers; .2) non-avoidance of carbon-intensive materials; 3) tendency not to choose lower carbon alternatives and 4) lack of knowledge with respect to carbon sequestering materials.

6.3 Research Question Three: What management systems should the government put in place to mitigate carbon emissions and promote climate resiliency?

6.3.1 Green Building Certification Systems

Responding to Research Question Three, the first systems management by government perceived to effectively mitigate carbon emission and promote climate resilience was found to be '*green Building Certificate Systems*. It scored (Medium (M) (0.4 ≤ RI < 0.6) (30%), High – Medium (H-M) (0.6 ≤ RI < 0.8) (5%) and Low(L) (0 ≤ RI < 0.2) (5%) by respondents. This suggested that only about 5% was in full agreement with contemporary global wish to developing an eco-friendlier construction through mandatory Green Building Certification System. Yet, *Green Building Certification Systems* have necessitated global rating systems to evaluate construction performance from sustainability and environmental perspective. Typical with such rating systems, LEED' (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) are recognized around the world. Adopting these strategies with awarding of certification could come with rewards such as tax incentives to buildings that meet a certain level of performance and quality. This could be a determining factor to motivating contractors and reducing carbon dioxide emissions in the environment.

6.3.2 High Rise And living Building elements

Another area that respondents were asked to rate was the issue of High Rise and living Building within the context of biodiversity in which plant and animals in both terrestrial and aquatic habitats and how they interact with the ecosystem could become impaired. Building construction and other construction related works often precipitate the clearing of space occupied by plant and animal species. By encouraging the development of high rise building in the country, the amount of terrestrial land is preserved and thereby preserving terrestrial biodiversity. Respondents' views varied from High – Medium (H-M) ($0.6 \leq RI < 0.8$, (4%), (Medium (M) ($0.4 \leq RI < 0.6$) (16%) (8%), Medium – Low(M-L) ($0.2 \leq RI < 0.4$) (12%) and Low(M-L) ($0.2 \leq RI < 0.4$) (8%)

6.3.3 Innovative Designs and Construction Methods

The use of natural resources and its effects on the environment during construction activities in Ghana can be minimized by using innovative designs and construction methods. Innovative designs such as dry construction can reduce the use of water during building construction. Dry construction includes the use of steel, glass and aluminum in our construction works. Modular Construction, that is the production of standardized component of a structure in an off-site factory, and then assembling them onsite is another method which not only reduces the amount of water used, but results in a significantly low level of waste generation due to the application of in-plant recycling. In all, these new technologies when adopted in Ghana result not only in environmental benefits but economic benefits as well. Respondents' views were as follows: High – Medium (H-M) ($0.6 \leq RI < 0.8$, (7%), (Medium (M) ($0.4 \leq RI < 0.6$) (13%) Medium – Low(M-L) ($0.2 \leq RI < 0.4$) (11%) and Low(M-L) ($0.2 \leq RI < 0.4$) (8%). Seven percent rated this new technology high, with eight percent rating it poorly.

7. Discussion

The core ideas from the above data suggest that while building construction workers in Ghana generally have basic fundamental ideas on the link between building construction and climate resilience and climate change mitigation, the major challenge appeared to be lack of pro-active attitude towards climate resilience. For example, response to research question 2, many scored low on the need for re-use and renovation of already existing structures, rather than starting all over to cause noise pollution and dust generation at construction site. More significantly, as indicated in the second research question, many building contractors per their responses were not seen to be migrating from the traditional way of carbon-intensive material towards carbon sequestering raw materials, such as wood, straw, hemp insulation, etc.

This has to do with attitude change. This tallies with what have become topical in the literature referred to as *Theory of Planned Behavior (TPB*). When individuals become aware that their behavior in construction is not beneficial to society, the presumption is that, the social expectations alone are enough to make the individual to become committed to act friendly towards the environment. Knowing that what they engage in, is more harmful than beneficial, there will be a positive change in attitude. This is in harmony with (Si et al., 2019; Li et al., 2019; Jean et al., 2020), who make the submission that promoting pro-environmental behavior is a planned behavior, especially migrating from the old ways of engaging in building construction which is more carbon-intensive, towards less carbon-intensive approach. This attitude reported here in this study strengthens that of Dent et al. (2021) that the type of intervention seen to have significant positive influence in stakeholders' attitude is not so much policy support as belief in climate change, and more significantly interventions to induce misinformation. Regardless of (97%) scientific evidence that climate change is human-caused, still in some geopolitical areas, such as the U.S, only 62% believe this. When viewed that this debate on green buildings originated from the perspective of its impact at the individual as well as community health perspective, it could generate planned behavior to optimize indoor spaces at the community level and to minimize air pollution that causes premature death, cardiovascular diseases, asthma and contributing to community and social health, especially of the vulnerable.

8. Conclusion

The fundamental conclusion that could be made in this survey report is that in the building sector, Ghana still has a long way to go, notwithstanding the nation's effort to transition to green economy which is evident in many policy documents. Ghana, like many other countries have taken steps to reduce climate change in many sectors generally, but the building sector seems not to have been given the needed highlights. Besides, few steps taken in this sector, have had limited impact on actual emission level as indicated in this report. This is based on the nature of the building sector itself, such as small reduction opportunities across many buildings, and different stakeholders having varied economic interests, which are often reflected in stakeholders' slow attitude to adopt green engineering as reported in this study. Given the fact that, modern technologies can minimize building construction-related energy by about 30-80 percent at the period of the building life-span, still many stakeholders in this study were found to be holding on to the carbon-intensive approach. Many construction firms which participated in this survey lacked internal management system of control to monitor and to assess whether or not climate mitigation benchmarks indices are being complied with.

9. Recommendations

Based on the above, the recommendation being made is that Government through the Ministry of Science, Technology and the Environment may need to enforce statutory regulation through strict adherence and constant supervision. Economic measures approach could also be adopted, such as tax reduction incentives, financial subsidies as well as green construction certification to promote contractors' awareness of climate resilience. Building contractors could form a forum/conference, especially international conferences/exchanges, etc. to promote professional development competencies in contemporary advanced construction technologies for mitigating building-related climate change.

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Appendix

The Relative Importance Index (RII) and the ranks of the impacts of construction activities on the environment.

Environmental Impacts	Structural engineers		Private contractors		Architects		Overall	
1.Resource Consumption	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Raw Materials	0.86	1	0.88	1	0.93	1	0.88	1
Fuel Consumption	0.85	2	0.82	2	0.73	3	0.81	5
Water consumption	0.81	3	0.80	3	0.90	2	0.82	4
Electricity consumption	0.7	4	0.74	4	0.50	4	0.73	7
2.Local Issues								
Dust Generation from Construction	0.6	2	0.70	2	0.56	2	0.65	8
Noise and vibration Generation	0.75	1	0.75	1	0.66	1	0.74	6
3.Effects on Biodiversity								
Vegetation removal	0.84	1	0.85	1	0.88	1	0.85	2
Interference with ecosystem	0.79	2	0.82	2	0.82	2	0.81	3
Interception of waterbodies	0.55	3	0.62	3	0.53	3	0.59	9
5.Other Issues								
Greenhouse gas emissions	0.7	1	0.50	2	0.47	2	0.56	10
Interference in road traffic	0.55	2	0.55	1	0.53	1	0.55	11