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[Sharon Asiamah-Agyeman](#) , [Emmanuel Awudzi](#) , [Tracy Ohene Adjei](#) , [Isaac Akomea-Frimpong](#) * , [Roksana Jahan Tumpa](#) , [Daniel Oteng](#) , [Fatemeh Pariafsai](#)

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Article

Barriers to Green Economy in the Construction Industry in Ghana

Sharon Asiamah-Agyeman ¹, Emmanuel Awudzi ¹, Tracy Ohene Adjei ¹, Isaac Akomea-Frimpong ^{2,*}, Roksana Jahan Tumpa ³, Daniel Oteng ⁴ and Fatemeh Pariafsai ⁵

¹ Department of Construction Technology & Management, Kwame Nkrumah University of Science & Technology, Kumasi, Ghana,

² School of Business, Excelsia University College, Sydney, Australia

³ School of Engineering and Technology, Central Queensland University, Sydney, Australia

⁴ School of Architecture and Civil Engineering, University of Adelaide, Adelaide, Australia

⁵ Department of Construction Management, Bowling State University, Green, USA

* Correspondence: isaac.akomea-frimpong@excelsia.edu.au

Abstract

Green economy is an important sustainable model that supports green practices and the achievement of sustainable development goals in the construction industry. However, the full-scale benefits of GE adoption in construction activities are short-lived by interconnected barriers in many developing economies such as Ghana. In particular, the transition to GE construction practices has been noted to hold a promising spot but it is undone by numerous challenges. Thus, this study aims at analyzing the barriers to green economy implementation in the construction industry in Ghana. The source of data was construction stakeholders using questionnaires. The data was analyzed with fuzzy synthetic evaluation to establish the critical barriers. The analysis revealed three key components of barriers including inadequate regulations, technological gap and poor practice framework on GE. The principal implications of the article are twofold. First, the clusters of barriers offer understanding and a guide to construction practitioners towards developing measures to overcome the major challenges on GE integration into construction works. Second, the study presents relevant outputs which deepen knowledge on GE in construction literature and provide essential areas for further studies.

Keywords: green economy; barriers; sustainable development goals; fuzzy synthetic evaluation

1. Introduction

The concept of 'green economy' emerged strongly after the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, which highlighted it as a development pathway capable of reconciling economic growth with ecological limits [1]. Since then, the concept has featured in major policy debates and was again brought to the center at the Rio+20 Summit in 2012, where it was presented as a main agenda [2]. The United Nations Environment Program broadly describes green economy as a model that improves social equity and well-being while lowering ecological risks and scarcities [3]. Adamowicz [4] and Shao, et al. [5] also explained green economy as a system that prioritizes social inclusion and equity as well as green environmental principles. To boost its implementation, the Green Economy Initiative was launched by the UNEP together with "Global Green New Deal," to help restructuring of global, national and industrial systems for ecosystem protection, poverty reduction and deplatform fossil-fuel dependence [6,7]. Within the construction industry, the shift to green economy models is seen as a crucial step to sustainability [8]. Green economy support waste management, reduction of carbon emissions, and improve resource efficiency in construction activities [9]. Although, the construction industry serves as a primary environmental polluter, which depletes natural resources and produces carbon emissions across the world, green economy models monitor and reduce their impacts on societies and the environment

[10,11]. Tucci [12] and Khoshnava, et al. [13] also espoused that green economy principles haven't proven sufficient to handle remote and immediate actions toward sustainable green construction management.

The global shift towards green economy continues to gain ground in the built environment but construction practices in many countries in the south of the global economy remain dependent on the exploitation of natural resources and systemic social injustices [14]. These developing nations such as Ghana are raising the awareness and putting measures to resolve developmental challenges in construction management with the incorporation of green economy [15]. However, these laudable efforts are fraught with many critical obstacles due to the early stages of incorporating green economy into the country's construction activities. A key obstacle in the Ghanaian context is slow institutional response to emerging construction models coupled with limited technical skills, and constrained financial support continues to hold the sector back. The construction industry in Ghana is still oriented by the colonial systems which prevailed pre- and post- 1957 independence era [16]. These colonial structures foster institutional bureaucracy which are deeply conservative and anti-progressive to embrace ecological and social changes [17,18]. Agyekum, et al. [19] further mentioned that a gap in the competency skills among built environment professionals exacerbate this challenge. Yeboah, et al. [20] argued that incompetent technical skills hinder green economy transition programs. Debrah, et al. [21] and Akomea-Frimpong, et al. [22] also demonstrated financial gap as a further challenge to transforming construction systems to embrace green economy within the country's construction sector. The mainstreaming of green economy within the construction management in Ghana is further handicapped by unreformed regulatory and policy frameworks [3]. There is no comprehensive legal framework in Ghana (and specifically to the construction industry) about green economy. Existing documents are randomly designed by construction firms and other key stakeholders to drive their own agenda without national cohesion and expansive legal support for GE transition for construction management. Moreover, there is a limiting legislation covering intellectual property, social capital, and inclusive practices for green construction practices. Concerns about suitable technologies to facilitate the transition to green economy have been raised by scholars. For instance, Pittri, et al. [23] mentioned that the Ghanaian construction industry is behind in adopting smart building technologies due to cultural resistance and the huge financial investments involved. Anzagira, et al. [24] and Tetteh, et al. [25] attributed this obstacle to software inefficiencies and limited space to implement robotic and wearable technologies for green economy transition. Against these backdrops, this study aims at empirically analyzing the critical barriers which hinder sustainable green economy implementation in the construction sector in Ghana. The remaining parts of the study include the presentation of the literature on important concepts, method for conducting research, data analysis and conclusions.

2. Literature Review

2.1. Green Economy

Green economy (GE) is a concept which explains the transition into ecological balance with sustainable development [26,27]. Different global institutions have provided different but similar explanations to what GE is. In the European Union's green strategy report, GE is explained as a smart and long-term framework with inclusive outlook for economic growth and ecological development [28]. GE is seen as a tool to promote inclusive education, poverty reduction and conscious efforts to cut down on environmental pollution from heavily industrialized countries of Europe. Organization of Economic Cooperation and Development, OECD [29] defined GE as a policy framework at the heart of sustainable economic development that efficiently applies natural resources and inclusive economic models. This intergovernmental organization among thirty-eight advanced nations presents thirty core indicators on the environment, social, financial and governance as the lens to realize GE growth at the national level. The United Nations Environment Programme UNEP [30] and

WorldBank [31] emphasized on the urgent actions towards cutting down emissions and addressing climate change for sustainable economic development.

GE is a combination of green sustainable elements such as zero pollution and efficient energy supplies that are its core principles. Zero pollution encompasses the nomenclature of normalizing the air, water, and land pollution to an extent which is not harmful to living and non-living organisms [32]. It stands to promote the adoption of practices that remove or minimize the use of toxic substances including industrial wastes by regulatory and industry guidelines. For instance, the European Union, World Green Building Council, and UNEP together with multilateral agreements such as Paris Climate Agreement and United Nation's Commitment to Net Zero are the forefront of encouraging actionable measures to reduce carbon emissions. As mentioned by the IPCC and UNFCCC, these decarbonization strategies have massive effects on addressing climate change, another core principle of GE, which has devastated cities, infrastructure and increased poverty. The third foundational principle of GE is energy efficiency that includes the use of clean energy sources and technologies for construction activities. Jones (2025) mentioned that this is a focal point of exchanging carbon emissions with green-bound energy sources such as solar and wind energies to supply buildings and infrastructures. The protection of flora, organic species, plants and animals in their natural habitats from unprovoked displacement of anthropological activities [33]. Another key component of GE is circular economy which is embedded in the reuse and recycling of resources for sustainable extension of lifespan of resources. GE is also inclusive of accountable and integrated governance with social justice.

2.2. Empirical Review of Barriers of Green Economy and Research Gaps

Globally, the transition to GE in the construction industry faces pertinent barriers which have been documented in empirical literature. Shi, et al. [34] explored the lapses in the regulatory and practice framework for green economy implementation the construction activities of fifteen sub-provincial cities within China. Although the study presented a novel model to incorporate GE models for sustainable cities, it lamented on the poor policy guidelines in sub-provincial unlike the mainland cities. A major contributor to this challenge inadequate green innovation and sustainability policies which are primary drivers of economic growth in contemporary Chinese rise to global superpower status. Unlike the Green New Deal of the United States (US), which spends \$1.3 trillion on green jobs and sustainable practices [35], Wang, et al. [36] mentioned that China's GE policies are yet to gain full actualization in the construction industry particularly in the provincial areas of the country. is one of the key policy responses facilitating this transition. The persistence of this challenge is evident developing economies where green economy has still remained a distant concept in project management due to undefined GE policies [37,38]. The policy draught extends to lack of political will to activate regulations to clamp down on over-reliance on fossil fuels for construction works [39]. This weakness is associated with national and institutional barriers such as inadequate leadership commitment, lax control systems, a gap in technological and skill for adoption of green energy innovations and financial risks. The growing disparities of social and cultural policy resolutions within the construction sector fuel barriers that compound the adoption of GE models. These barriers are centered around stakeholder conflict, cultural opposition, low community participation and lack of awareness of the GE for sustainable infrastructure development. Though some studies have pointed out these challenges in the Ghanaian context, the literature is skewed towards economic development and job creation particularly the digitization [40], carbon neutrality [41], and job creation [20]. Additionally, these studies failed to offer baseline knowledge on major green economy adoption such as social issues and circular economy. The construction sector in Ghana has been either left out or minimally mentioned in these studies giving room for studies in that industry. Specifically, Gyimah, Owusu-Manu, Edwards, Buertey and Danso [15] is the principal research output that has investigated the benefits of GE adoption in the Ghanaian construction industry but the study concluded by mentioning the need for further studies about barriers about the concept.

Methodologically, the study suffered from limited sample size and exploratory factor analysis which has been criticized for its subjectivity, reliability and poor reporting standards.

3. Methodology

3.1. Source of Data

A quantitative approach to research was applied to achieve the aim of this study. The research instrument to aid sourcing data for this research approach is a survey questionnaire. This is suitable for the study because quantitative data instrument like survey are dependent on the positivist philosophy which enhances the carrying out data and analysis to ascertain an objective reality. Additionally, this instrument has been widely utilised in construction management literature to identify and rate the opinions of stakeholders. The two-part questionnaire contains demographic profile of participants including their job titles, working experience, projects undertaken in the past, and education qualification in the first section. The second part of the questionnaire encompasses a list of barriers of green economy (see Table 1).

Table 1. Key barriers on GE.

Serial number	GE barriers	Reference
GEB1	Inadequate data to track green performance	[13], [9]
GEB2	Lack of awareness among construction professionals	[12], [36]
GEB3	Inadequate skillset to transition to green economy	[35]
GEB4	Poor technological transfer	[8]
GEB5	Low innovation to sustain a green economy	[10]
GEB6	Raging climate risks	[42]
GEB7	Untapped green potentials to support construction works	[43]
GEB8	Inadequate funding for green economy research	[44]
GEB9	Not incorporating green policies into organization systems	[31]
GEB10	Poor coordination of green implementation strategies	[20]
GEB11	Lack of leadership commitment	[45]
GEB12	Insufficient project-based controls on the green economy	[46]
GEB13	Lack of political will and action	[47]
GEB14	Inadequate environmental policies	[4], [34]
GEB15	Undefined green economy limits for construction activities	[48]
GEB16	Financial risks	[11]
GEB17	Cultural barriers	[49]
GEB18	Multiple stakeholder interests and conflicts	[50]
GEB19	Low accountability to greenwashing practices	[51], [26]
GEB20	Lack of community engagement	[15]
GEB21	Difficulty in tracking green performance	[28]
GEB22	Resistance to change to sustainable practices	[29]
GEB23	Complex and unapplicable legislative directives	[32]
GEB24	Continuous use of fossil fuel construction materials	[36], [41]

All the barriers were rated on the Likert scale ranging from one to five. To ascertain its validity, the questionnaire was pilot tested using twelve experienced experts (four senior academic

researchers and eight construction industry construction professionals) who have more than ten-year experiences. The feedback from the experts during the pilot testing stage enhanced the questionnaire's clarity, validity, and comprehensiveness of the questionnaire items, as well as identifying any potential issues or biases before the full-scale survey was administered. To distribute the questionnaire, the research population who are the subject matter of the study was established as the stakeholders of the construction industry in Ghana. The inclusion criteria to be part of this survey was specified as: 1) a stakeholder in the Ghanaian construction industry, working in the private or public sector; 2) someone who has ten-year or more experience working the construction industry, and 3) a person with enough knowledge about green economy. A deliberate effort was made to reach out to the stakeholders on this study through the various social media and professional network platforms. Initially, sixteen potential participants purposively expressed interest in the survey, and they were identified on LinkedIn. These participants relayed an invitation to other participants who were work colleagues and important industry people. This process boosted the number of potential participants to two hundred and eight (208). The compilation of contact details (emails) was assembled after which a generated link of the questionnaire from Google Forms was sent to the participants. In total, 114 participants responded fully to the email by filling all sections of the questionnaire, yielding a response rate of 54.81%. Comparatively, 54.81% is considered representative in comparison with studies such as 20% [52], 44% [11], and 14% [53] response rates of previous studies within the construction research domain.

3.2. Data Analysis

The data from the survey was analysed within the IBM SPSS Software. First, the fundamental measurement items were analysed to establish the criticality of the barriers and check the robustness of the dataset using techniques such as the reliability test to examine the internal consistency and normality of the items specified. The Cronbach Alpha revealed a score of 0.891 affirming the reliability of the dataset [54]. Furthermore, the distribution of the dataset was verified by the Shapiro-Wilk normality model. The test results suggest that the dataset does not meet the cut off normality ($p < 0.05$) [55]. As a result of the non-normal distribution of the data, the Kruskal-Wallis (KW), an opposite of the analysis of variance (ANOVA) was applied to assess the varied perspectives of participants [56]. The outcomes of the KW indicate no statistically significant difference between the scores of the green economy barriers. The next step is factor analysis (FA) and it was conducted to seek the relevant groups of barriers. Apart from the Cronbach Alpha, the underlying fitness tests of the factor analysis ensued to measure the strength of relationships of the various groups from the FA analysis [57]. The Kaiser-Meyer-Olkin test on the FA analysis checked the sampling adequacy of the data set, and it yielded a statistical score of 0.891. The Bartlett's test of sphericity was also calculated on the degree of collinearity between the factors, and it yielded an output of $p < 0.05$ with a chi-square of 3225.761. The correlation matrix helped to check the multi-collinearity within the data set of the generated groups [58]. Finally, the fuzzy synthetic evaluation (FSE) as outlined comprehensively in Section 4.4 was conducted to establish the ranking of the factor groupings from the FA [25]. The processes within FSE include the formulation of the weighting and membership functions with the support of the mean score in Table 2. The third component of the FSE is the computation of the indices which is important for ranking the order of importance of the groups from the FA analysis.

Table 2. Basic information about participants.

Profile	Description
Career title	Regulators (43%), financiers (22%), architects (14%), project managers (11%), academics (7%) and quantity surveyors (3%)
Years of working	10-15 years (47%), 16-20 years (36%), Beyond 20 years (17%)
Education	Bachelors (53%), masters (24%), professional certificates (15%) and doctorate (8%)

Projects involved 5-10 projects (40%), 1-4 projects (28%), 11-15 projects (23%), and beyond 15 projects (9%).

4. Results

4.1. Demographic Profile of Participants

The summary of the demographic information about the 114 responses is presented in Table 2 demonstrating the diversity of various key stakeholders within the Ghanaian construction industry. The stakeholders comprise of regulators, financiers, architects, project managers, academics, and quantity. In terms of number of years of experience, most respondents had 10-15 years of work experience, while a minority had 16-20 years and beyond 20 years. With education qualification, most respondents had either bachelor's degree followed by master's degrees and professional certificate in construction management, while minorities had doctoral qualifications as shown in Table 2. Most of participants have significantly been involved in 5-10 projects either as supervisors or workers with the least of projects cohorts being 15 and beyond.

4.2. Descriptives of the Barriers

As shown in Table 3, the means of the green economy barrier (GEB) variables are arranged according to the importance determined by their means. These rankings demonstrate the relative importance to the barriers as pointed out by the survey participants. The topmost three critical barriers are lack of leadership commitment (GEB11), inadequate environmental policies (GEB14), and insufficient project-based controls on the green economy (GEB12) with a corresponding means of 4.46, 4.44, and 4.43, respectively. The two least criticalities of the means are identified with the continuous use of fossil products (GEB24) and awareness among professionals on green economy (GEB2). This could be indication of the resistance or slow change of construction practitioners in Ghana to move from anti-green construction measures. The realization of the data being undistributed from the normality test in Table 3, informed the running of the KW test where stakeholders hold no different perspectives about the challenges to implementing green economy in the Ghanaian construction practices.

Table 3. Summary on barriers data.

S/N	Green economy barriers	Mean	SD	Rank	Shapiro-Wilk Normality test	Kruskal-Wallis test
GEB11	Lack of leadership commitment	4.46	0.817	1	0.000	0.072
GEB14	Inadequate environmental policies	4.44	0.851	2	0.000	0.107
GEB12	Insufficient project-based controls on the green economy	4.43	0.815	3	0.000	0.204
GEB13	Lack of political will and action	4.43	0.850	4	0.000	0.510
GEB20	Lack of community engagement	4.27	0.935	5	0.000	0.404
GEB22	Resistance to change to sustainable practices	4.26	0.911	6	0.000	0.203
GEB4	Poor technological transfer	4.21	1.180	7	0.000	0.365
GEB21	Difficulty in tracking green performance	4.21	0.916	8	0.000	0.203
GEB9	Not incorporating green policies into organization systems	4.19	0.962	9	0.000	0.521
GEB7	Untapped green potentials to support construction works	4.18	0.999	10	0.000	0.207
GEB10	Poor coordination of green implementation strategies	4.16	0.982	11	0.000	0.304
GEB8	Inadequate funding for green economy research	4.15	0.969	12	0.000	0.200

GEB23	Complex and unapplicable legislative directives	4.14	1.005	13	0.000	0.115
GEB6	Raging climate risks	4.05	1.360	14	0.000	0.276
GEB3	Inadequate skillset to transition to green economy	3.99	1.346	15	0.000	0.323
GEB5	Low innovation to sustain a green economy	3.91	1.463	16	0.000	0.265
GEB15	Undefined green economy limits for construction activities	3.61	0.510	17	0.000	0.126
GEB19	Low accountability to greenwashing practices	3.57	0.536	18	0.000	0.108
GEB17	Cultural barriers	3.57	0.536	19	0.000	0.210
GEB18	Multiple stakeholder interests and conflicts	3.55	0.538	20	0.000	0.109
GEB16	Financial risks	3.49	0.540	21	0.000	0.202
GEB1	Inadequate data to track green performance	2.88	1.322	22	0.000	0.104
GEB24	Continuous use of fossil fuel construction materials	2.18	1.277	23	0.000	0.297
GEB2	Lack of awareness among construction professionals	1.77	1.226	24	0.000	0.208

4.3. Factor Analysis

The main categories of groups with underlying sub-group factors of the GEB variables were automatically identified in this section using exploratory factor analysis (EFA). Within the SPSS software, EFA function under the dimension reduction with factors was chosen within the analyzing tab of the software. The foundational metrics such as Bartlett test of sphericity, and KMO were determined where the results are shown in Section 3.2. The principal component analysis (PCA), an extraction was selected to ascertain the key groups because it has been tested to possess stronger dimension reduction characteristics compared to other extraction methods. Additionally, PCA fits into the extraction and classification of datasets which are loosely correlated. The appropriate rotation method to supplement the EFA was the Varimax. Aside from its orthogonal superiority, the varimax maximizes the significant differences and correlative dimensions of the groups and the sub-group variables comparative to other rotation techniques [59,60]. In summary, three main groups (principal GEB group factors) resulted from the EFA as demonstrated in Table 3 with total variance explained of 75.4%.

Table 4. Principal groups on GEB using exploratory factor analysis.

S/N	Green economy metrics	Factor loadings	Eigenvalues	VE	CVE
CGEB1	Poor practice framework on green economy		14.074	58.644	58.644
GEB21	Difficulty in tracking green performance	0.949			
GEB20	Lack of community engagement	0.933			
GEB22	Resistance to change to sustainable practices	0.920			
GEB9	Not incorporating green policies into organization systems	0.910			
GEB15	Undefined green economy limits for construction activities	0.905			
GEB7	Untapped green potentials to support construction works	0.904			
GEB10	Poor coordination of green implementation strategies	0.898			
GEB1	Inadequate data to track green performance	0.897			

GEB8	Inadequate funding for green economy research	0.884			
GEB19	Low accountability to greenwashing practices	0.884			
GEB17	Cultural barriers	0.863			
GEB11	Lack of leadership commitment	0.853			
GEB18	Multiple stakeholder interests and conflicts	0.848			
GEB12	Insufficient project-based controls on the green economy	0.845			
GEB14	Inadequate environmental policies	0.821			
GEB16	Financial risks	0.813			
CGEB2	Deficiency of IT and green economy skills		3.010	12.540	71.184
GEB6	Raging climate risks	0.830			
GEB5	Low innovation to sustain a green economy	0.751			
GEB3	Inadequate skillset to transition to green economy	0.737			
GEB4	Poor technological transfer	0.709			
CGEB3	Inadequate stringent regulations		1.020	4.250	75.434
GEB24	Continuous use of fossil fuel construction materials	0.874			
GEB13	Lack of political will and action	0.825			
GEB23	Complex and unapplicable legislative directives	0.773			

4.4. FSE Analysis

4.4.1. Weighting Scores

The first step in the FSE analysis within this study is the calculation of the weighting scores of both the principal groups and their factors based on the results in Section 4.3. The value of the weightings represents the portion of the group occupied by the factors. It is calculated using the means in Table 2, and it follows the formula below.

Table 5. Weighting scores of the principal and sub-components.

S/N	Principal groups of the CEBs	Means of CEBs	Weightings of CEBs	Means total of CEBGs	Weightings of CEBGs
CGEB1	Poor practice framework on green economy			63.42	0.702
GEB21	Difficulty in tracking green performance	4.21	0.066		
GEB20	Lack of community engagement	4.27	0.067		
GEB22	Resistance to change to sustainable practices	4.26	0.067		
GEB9	Not incorporating green policies into organization systems	4.19	0.066		
GEB15	Undefined green economy limits for construction activities	3.61	0.057		
GEB7	Untapped green potentials to support construction works	4.18	0.066		
GEB10	Poor coordination of green implementation strategies	4.16	0.066		
GEB1	Inadequate data to track green performance	2.88	0.045		
GEB8	Inadequate funding for green economy research	4.15	0.065		

GEB19	Low accountability to greenwashing practices	3.57	0.056		
GEB17	Cultural barriers	3.57	0.056		
GEB11	Lack of leadership commitment	4.46	0.070		
GEB18	Multiple stakeholder interests and conflicts	3.55	0.056		
GEB12	Insufficient project-based controls on the green economy	4.43	0.070		
GEB16	Financial risks	3.49	0.055		
GEB14	Inadequate environmental policies	4.44	0.070		
CGEB2	Deficiency of IT and green economy skills			16.16	0.179
GEB6	Raging climate risks	4.05	0.251		
GEB5	Low innovation to sustain a green economy	3.91	0.242		
GEB3	Inadequate skillset to transition to green economy	3.99	0.247		
GEB4	Poor technological transfer	4.21	0.261		
CGEB3	Inadequate stringent regulations			10.75	0.119
GEB24	Continuous use of fossil fuel construction materials	2.18	0.203		
GEB13	Lack of political will and action	4.43	0.412		
GEB23	Complex and unapplicable legislative directives	4.14	0.385		
				$\Sigma=90.33$	

$$wths_i = \frac{Mean_i}{\sum_i^n Mean_i}, 0 \leq wths_i \leq 1, \text{ and } \sum_{i=1}^n wths_i = 1$$

where $Mean_i$ is the GEB mean from Table 2, and $Wths_i$ is the weightings (WS) of a GEB. The number of sub-group variables (that is the GEBs) is denoted by i and n . For instance, the mean value of GEB 21 is 4.21 and it is part of Group 1 (CGEB) that has a mean sum of 63.42 in Table 5. Therefore, GEB21's WS is determined as:

$$wths_{GEB21} = \frac{4.21}{4.21 + 4.27 + 4.26 + 4.19 + 3.61 + 4.18 + 4.16 + 2.88 + 4.15 + 3.57 + 3.57 + 4.46 + 3.55 + 4.43 + 3.49 + 4.44} = \frac{4.21}{63.42} = 0.066$$

The same technique is applied to attain all the individual GEB weightings throughout Table 4. Further, weighting scores of the three groups were calculated using the same approach:

$$wths_{GEBG1} = \frac{63.42}{63.42 + 16.16 + 10.75} = \frac{63.42}{90.33} = 0.702$$

$$wths_{GEBG2} = \frac{16.16}{63.42 + 16.16 + 10.75} = \frac{23.92}{90.33} = 0.179$$

$$wths_{GEBG3} = \frac{10.75}{63.42 + 16.16 + 10.75} = \frac{15.86}{90.33} = 0.119$$

4.4.2. Membership Function

The second step in the FSE is the determination of the membership function (MF) of the GEB groups and sub-components [25]. The MF applies the fuzzy analysis's linguistic approach to mathematically assign variables values between 0 and 1 from the rate of responses from the participants. Simply, the proportion of answers on the Likert scale (1 to 5) rated by participants on each GEB is a key determinant of the MF. For example, the MF of GEB21 in Table 6 was determined by considering the responses on it: 53.90% for strongly agree (5), 12.70% for agree (4), 33.30% for

neutral (3), 0.00% for disagree (2), and 0.00% strongly disagree (1). The formula that sets this rating outcome is:

$$MF_{GEB21} = \frac{0.000}{StDr(1)} + \frac{0.000}{Dr(2)} + \frac{0.333}{Nel(3)} + \frac{0.127}{Agr(4)} + \frac{0.539}{Str(5)}$$

This is converted into (0.000, 0.000, 0.333, 0.127, 0.539) for GEB21. Similar procedure is utilized to produce all the MF for the remaining MFs in Table 6. Next, the weightings of GEBs in Table 5 are multiplied by MFs of the GEBs to produce the group-based MFs of the CGEBs using the fuzzy evaluation matrix formula of:

$$FSE(Dm)_i = Wthsi \bullet MF_i$$

where “•” indicates the composite operator, MF_i is the membership function of the GEBs, $Wthsi$ is the weightings, and $FSE(Dm)_i$ is the FSE evaluation matrix. The formula is shown below.

Table 6. Constituents of the membership functions of the GEBs.

S/N	Green Economy Barriers	Weightings	MF of GEBs	MF of GEBGs
CGEB1	Poor practice framework on green economy			(0.013, 0.031, 0.267, 0.308, 0.381)
GEB21	Difficulty in tracking green performance	0.066	(0.000, 0.000, 0.333, 0.127, 0.539)	
GEB20	Lack of community engagement	0.067	(0.000, 0.010, 0.304, 0.088, 0.598)	
GEB22	Resistance to change to sustainable practices	0.067	(0.000, 0.000, 0.314, 0.108, 0.578)	
GEB9	Not incorporating green policies into organization systems	0.066	(0.000, 0.020, 0.324, 0.108, 0.549)	
GEB15	Undefined green economy limits for construction activities	0.057	(0.000, 0.010, 0.373, 0.618, 0.000)	
GEB7	Untapped green potentials to support construction works	0.066	(0.010, 0.020, 0.304, 0.118, 0.549)	
GEB10	Poor coordination of green implementation strategies	0.066	(0.000, 0.029, 0.324, 0.108, 0.539)	
GEB1	Inadequate data to track green performance	0.045	(0.275, 0.108, 0.078, 0.539, 0.000)	
GEB8	Inadequate funding for green economy research	0.065	(0.000, 0.020, 0.343, 0.108, 0.529)	
GEB19	Low accountability to greenwashing practices	0.056	(0.000, 0.020, 0.392, 0.588, 0.000)	
GEB17	Cultural barriers	0.056	(0.000, 0.020, 0.392, 0.588, 0.000)	
GEB11	Lack of leadership commitment	0.070	(0.000, 0.069, 0.000, 0.333, 0.598)	
GEB18	Multiple stakeholder interests and conflicts	0.056	(0.000, 0.020, 0.412, 0.569, 0.000)	
GEB12	Insufficient project-based controls on the green economy	0.070	(0.000, 0.069, 0.000, 0.363, 0.569)	
GEB16	Financial risks	0.055	(0.000, 0.020, 0.471, 0.510, 0.000)	
GEB14	Inadequate environmental policies	0.070	(0.000, 0.078, 0.000, 0.324, 0.598)	
CGEB2	Deficiency of IT and green economy skills			(0.080, 0.088, 0.127, 0.118, 0.586)
GEB6	Raging climate risks	0.251	(0.069, 0.118, 0.127, 0.069, 0.618)	
GEB5	Low innovation to sustain a green economy	0.242	(0.127, 0.078, 0.108, 0.127, 0.559)	

GEB3	Inadequate skillset to transition to green economy	0.247	(0.088, 0.069, 0.167, 0.118, 0.247)
GEB4	Poor technological transfer	0.261	(0.039, 0.088, 0.108, 0.157, 0.608)
CGEB3	Inadequate stringent regulations		(0.085, 0.098, 0.148, 0.209, 0.460)
GEB24	Continuous use of fossil fuel construction materials	0.203	(0.402, 0.284, 0.118, 0.127, 0.069)
GEB13	Lack of political will and action	0.412	(0.000, 0.078, 0.000, 0.333, 0.588)
GEB23	Complex and unapplicable legislative directives	0.385	(0.010, 0.020, 0.324, 0.118, 0.529)

$$FSE(DM)_i = \{wths_1, wths_2, wths_i, \dots, wths_n\} \cdot \begin{bmatrix} MF_{11} & MF_{12} & MF_{13} & MF_{14} & MF_{15} \\ MF_{21} & MF_{22} & MF_{23} & MF_{24} & MF_{25} \\ MF_{31} & MF_{32} & MF_{33} & MF_{34} & MF_{35} \\ \dots & \dots & \dots & \dots & \dots \\ MF_{m1} & MF_{m2} & MF_{m3} & \dots & MF_{nt} \end{bmatrix}$$

The application of the formula to CGEB3 with weightings of [0.203, 0.412, 0.385] and MF of

$$MF_{GEB3} = \begin{bmatrix} 0.402 & 0.284 & 0.118 & 0.127 & 0.069 \\ 0.000 & 0.078 & 0.000 & 0.333 & 0.588 \\ 0.010 & 0.020 & 0.324 & 0.118 & 0.529 \end{bmatrix}$$

The result is:

$$FSE(Dm)_{GEB3} = [0.203, 0.412, 0.385] \cdot \begin{bmatrix} 0.402 & 0.284 & 0.118 & 0.127 & 0.069 \\ 0.000 & 0.078 & 0.000 & 0.333 & 0.588 \\ 0.010 & 0.020 & 0.324 & 0.118 & 0.529 \end{bmatrix} \\ = [0.085, 0.098, 0.148, 0.209, 0.460]$$

The rest of the MFs of the CGEBs are computed by using the same formula.

4.4.3. Determination of Critical Indexes

The fuzzy matrix in Section 4.4.2 (Table 5) is combined with alternate grades to get the critical indexes. The set of alternative grades are 1 to 5 multiplied by the fuzzy matrix which establishes a formula of:

$$SSSG_{index} = \sum_{i=1}^3 (FSE(Dm)_i \times AGr_i)$$

$SSSG_{index}$, is the criticality index, $FSE(Dm)_i$ is the fuzzy matrix, and $AGr_i = (1,2,3,4,5)$ is the Likert scale's grades. The formula is used to determine the critical indexes as:

$$GEBG1 = (0.013, 0.031, 0.267, 0.308, 0.381) \times (1,2,3,4,5) \\ = (0.013 * 1 + 0.031 * 2 + 0.267 * 3 + 0.308 * 4 + 0.381 * 5) = 4.012(2nd) \\ GEBG2 = (0.080, 0.088, 0.127, 0.118, 0.586) \times (1,2,3,4,5) \\ = (0.080 * 1 + 0.088 * 2 + 0.127 * 3 + 0.118 * 4 + 0.586 * 5) = 4.042(1st) \\ GEBG3 = (0.085, 0.098, 0.148, 0.209, 0.460) \times (1,2,3,4,5) \\ = (0.085 * 1 + 0.098 * 2 + 0.148 * 3 + 0.209 * 4 + 0.460 * 5) = 3.861(3rd)$$

Lastly, the overall criticality index of the dataset is computed by multiplying the group-based MFs, the weightings of the three groups from Table 4 and 5, and the alternative grades.

The group weighting: $Wths_{GEBG} = (0.702, 0.179, 0.119)$ and the MF is

$$FSE(Overall)_i = \begin{bmatrix} 0.013 & 0.031 & 0.267 & 0.308 & 0.381 \\ 0.080 & 0.088 & 0.127 & 0.118 & 0.586 \\ 0.085 & 0.098 & 0.148 & 0.209 & 0.460 \end{bmatrix}$$

The overall fuzzy matrix of GEBG is calculated as:

$$GEBG(overall)_i = \{wths_1, wths_2, \dots, wths_n\} \cdot \begin{bmatrix} MF_{11} & MF_{12} & MF_{13} & MF_{14} & MF_{15} \\ MF_{21} & MF_{22} & MF_{23} & MF_{24} & MF_{25} \\ MF_{31} & MF_{32} & MF_{33} & MF_{34} & MF_{35} \\ \dots & \dots & \dots & \dots & \dots \\ MF_{m1} & MF_{m2} & MF_{m3} & \dots & MF_{nt} \end{bmatrix}$$

$$GEBG(Overall)_i = (0.702, 0.179, 0.119) \cdot \begin{bmatrix} 0.013 & 0.031 & 0.267 & 0.308 & 0.381 \\ 0.080 & 0.088 & 0.127 & 0.118 & 0.586 \\ 0.085 & 0.098 & 0.148 & 0.209 & 0.460 \end{bmatrix}$$

$$GEBG(overall)_i = (0.034, 0.049, 0.228, 0.262, 0.427)$$

The final overall critical index of the CGEB is computed as:

$$GEBG_{critical\ index} = (0.034, 0.049, 0.228, 0.262, 0.427) \times (1, 2, 3, 4, 5)$$

$$= (0.034 * 1) + (0.049 * 2) + (0.228 * 3) + (0.262 * 4) + (0.427 * 5)$$

$$= 4.000$$

5. Discussion

5.1. Poor Practice Framework on Green Economy

The first factor was the most influential with the highest critical index in the fuzzy analysis. The absence of leadership commitment (mean = 4.46), inadequate environmental policies (mean = 4.44), insufficient project controls (mean = 4.43), low community engagement (mean = 4.27), and resistance to change (mean = 4.26) dominated this factor. The dominance of these factors indicates that the transition challenge in Ghana is fundamentally institutional rather than technical. The results highlight the disproportionate governance gap in Ghana's construction sector, characterized by poor leadership, fragmented institutional coordination, and policy discontinuity, all of which hinder the translation of sound sustainability goals into practice. The same applies to Shi, Yang, Wang and Zhao [34] and Gibbs and O'Neill [61], who acknowledged that sustainability-focused policy frameworks in developing environments are left rhetorical by default because of poor institutional accountability and regulation enforcement. In fact, in developing countries' context most firms are resistant to challenges. They mostly prefer things to be done in the traditional means. This further limit the adoption of the circular economic principles. It is worth mentioning that inadequate data tracking green performance was the lowest ranked (mean = 2.88) factor in this cluster, which makes it an irrelevant barrier in the developing countries context. There is low level of adoption of sustainability technologies so as such, the respondents see this factor not to be a barrier to them. However, when looking at it from the developing countries context, because there is high level of technological adoption, this barrier really persists.

5.2. Deficiency of IT and Green Economy Skills

The second element includes poor technical transfer (mean = 4.21), inadequate skillset to transition to green economy (mean = 3.99), and low innovation to sustain a green economy (mean = 3.91). Factor analysis identified them as a group with a 'lack of IT and green economy competencies.' This demonstrates the Ghanaian construction industry's limited ability to obtain, adopt, and use green technologies. Despite increased low-carbon and digital construction activities globally, the construction conditions of Ghana still need to deal with low adoption of high-end equipment, low levels of training, and low funding for innovation. This supports Wang, Sun and Li [7], who attested that poor liaison between research and industry and poor innovation systems remain prevalent barriers towards sustainability for emerging economies. The results further concur with Gyimah, Owusu-Manu, Edwards, Buertey and Danso [15], who emphasized that the absence of technological know-how and poor investment in training hinder green innovation in Africa's construction sector. Moreover, the absence of composite digital platforms such as BIM-integrated carbon calculators, renewable-energy technologies, Life Cycle Assessment tools like EcoInvent and ICE databases, to track carbon emissions, coordinate project lifecycle performance, and gauge sustainability returns is a contributing factor to inefficiencies [62]. Capacity development programs, industry-academia

partnerships, and digital-skills training, hence, have significant roles in bridging the knowledge gap and accelerating the greening of Ghana's built environment.

5.3. Inadequate Stringent Regulations

The third component comprises a lack of political will, complex and unapplicable legislative directives (mean = 4.14), and the ongoing reliance on fossil fuel-based construction materials (mean = 2.18). Although they scored significantly lower than institutional constraints, they remain significant because they impede policy enforcement and regulatory control. Inconsistent regulations lead to differences in application, while fossil fuel usage defies sustainability. The fuzzy analysis revealed that the limitations play a significant role in shaping this sector's behavior. The Environmental Protection Agency (EPA) provides environmental-impact assessment guidelines, though there are no specified sanctions for breach of sustainability practice in construction. Similarly, current building codes do not make energy efficient or recycling mandatory. Respondents emphasized that political will is often limited, with green initiatives losing progress after changes in government. This aligns with Bonoli, Zanni and Serrano-Bernardo [35] and Khan, Razak, Premaratne and Aremu [32], who noted that fragmented policy enforcement and political leadership discontinuity are key explanations for slow green-economy development in developing nations. The study also revealed that some legislative provisions are too complex or irrelevant, discouraging practitioners from adhering to them. To combat such challenges, Ghana needs effective and enforceable regulations that directly deal with the construction sector. For example, the application of mandatory green building codes, tax incentives for green projects, and penalties for massive carbon emissions could generate higher incentives for compliance. Developing an autonomous green-building council in Ghana with regulatory powers could also increase transparency and accountability towards green economy construction practices.

6. Implications

This study advances both theoretical understanding and practical application of the green economy concept within the construction sector. Theoretically, it contributes by categorizing the complex barriers to green-economy transition into three empirically validated and interrelated factors: poor practice framework on green economy, deficiency of IT and green-economy skills, and inadequate stringent regulations from a developing country, Ghana. This classification provides a coherent structure for examining the multidimensional nature of sustainability challenges in the context of Ghana and similar global south countries where institutional and technological capacities are still evolving. Unlike earlier studies that addressed individual constraints such as policy gaps [26] or skill shortages [61], this research presents critical barriers on technology, climate change and policy towards green-economy adoption. This expands theoretical perspectives on impediments against sustainability transitions by positioning them as holistic and interrelated challenges rather than discrete or isolated issues. The analysis in this study offers a underlying knowledge for future researchers can adapt to test interdependencies between principal obstacles to advance green economy in construction research. Practically, the study provides a clear roadmap for bridging the gap between green-economy policy and on-site construction practice. The findings highlight the need for stronger leadership commitment, rationalized policy structures, and investment in capacity building for technology adoption. The study offers understanding to various construction stakeholders of the challenges and potential solutions relating to institutional reforms that embed sustainability clauses into public procurement procedures and professional licensing systems. Similarly, viable solutions to technologies for green economy are presented inclusive of digital training programs and initiatives renewable energy technology integration, and carbon-tracking systems.

7. Conclusion

This study investigated the barriers hindering the transition toward a green economy within Ghana's construction sector using fuzzy synthetic method. The findings revealed three principal categories of barriers: poor practice frameworks on green economy, deficiency of IT and green economy skills, and inadequate stringent regulations. Among these, barriers such as lack of leadership commitment, poor coordination of sustainability initiatives, and limited community engagement were identified as the most critical, underscoring the need for stronger governance and leadership accountability in promoting sustainable construction. The results emphasize that leadership vision and institutional alignment are pivotal for sustainable green economy transformation in Ghana's construction industry. Technological and skill deficiencies, particularly low innovation, poor technology transfer, and inadequate capacity in digital construction, further restrict adoption. That means limited technical expertise and weak research-industry collaboration impede green transition efforts for construction development. Another important outcome of the study is inadequate stringent regulations which reflect policy gaps and ineffective enforcement mechanisms, echoing Ghana's underdeveloped regulatory regime to support sustainability and green practices not only in the construction industry but other sectors.

To address these interconnected barriers, it is recommended that an integrated approach centered on governance, technology, and regulation should be encouraged in the built environment. First, institutional leadership must be strengthened through the mainstreaming of sustainability objectives in national building codes and procurement policies. Government agencies such as the Ministry of Works and Housing and the Environmental Protection Agency (EPA) in Ghana should mandate green targets across all public projects, while professional institutions such as the Ghana Institution of Engineers (GhIE), Ghana Institute of Architects (GIA), and Ghana Institution of Surveyors (GhIS) should embed sustainability standards into their professional training and ethical codes. Second, technological capability and innovation must be enhanced through structured capacity-building programs, collaboration between universities and industry, and integration of smart and low-carbon digital tools into construction practice. These echo Onubi, et al. [63] and Wang, Chong and Liu [36], who identified technology diffusion and skills upgrading as key drivers of green-economy transitions. Third, regulatory reform and financial mechanisms must be strengthened to encourage compliance and investment. Low-cost financing schemes such as green bonds, concessional credit lines, and tax incentives should be established in collaboration with local banks, development finance institutions (e.g., Ghana Infrastructure Investment Fund), and international partners (e.g., World Bank, UNDP). Fourth, Ghana's construction industry inclusive of construction firms must spearhead a paradigm shift toward integrating green economy into both organizational and project-base practices. Realizing this vision requires concerted action from top leadership commitment, industry regulators, construction workers and academia to provide green economy solutions to dismantle systemic barriers and embed sustainability as a fundamental principle of construction development.

Notwithstanding, the study has limitations which should be addressed in future studies. First, the extent of policy reforms on green economy adoption was not adequately assessed in this study. Further studies should examine how policy reform and institutional alignment can enhance green-economy implementation. For example, researchers could assess how revising Ghana's Building Code or integrating sustainability clauses into the Public Procurement Act might strengthen compliance and accountability within the construction sector. A second area for investigation is financing barriers. Further studies should examine the design of funding mechanisms and incentive schemes that support green innovation. Studies could explore how initiatives such as green bonds, public-private partnerships (PPPs), or tax incentives influence investment in sustainable construction technologies. Thirdly, there is still technological gap in the green economy for construction activities. Future work in Ghana and similar developing countries should address the role of digital and innovative platforms in advancing green economy towards sustainable development goals. Fourth, comparative research between Ghana and other developing countries would also provide valuable insight into which barriers are context-specific, and which are common across developing economies.

Fifthly, limited sample size should be expanded including stakeholders such construction workers, suppliers and sub-contractors to ascertain the extent of the challenges towards green economy adoption.

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