

Promoting the Adoption of Sustainable Environmental Technologies in Ghana's Construction Sector: A Quantitative Study of Key Drivers

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Abstract

This study aims to quantitatively assess the key drivers influencing the adoption of sustainable environmental construction technologies (ECTs) in Ghana's construction sector. A structured survey was conducted with 275 professionals from the Ghana Real Estate Developers Association (GREDA), the Ghana Institution of Engineering (GhIE), the Institution of Engineering and Technology (IET), and the Architects Registration Council (ARC). A five-point Likert scale was used in the evaluation. Data was analysed using descriptive statistics and correlation analyses to identify key enablers of ECT adoption. The study is constrained geographically, and future research should incorporate a wider variety of stakeholders and geographic regions to enhance the generalizability of the findings. The correlation analysis revealed strong associations between energy efficiency and regulatory policies ($\rho = 0.678$, $p < 0.01$) and between financial incentives and technological advancements ($\rho = 0.521$, $p < 0.01$), highlighting the critical role of policy and financial mechanisms in driving sustainable technology adoption. The study recommends the creation of more substantial financial incentives and clearer regulatory and policy frameworks to promote ECT adoption. Enhancing awareness campaigns on the economic and environmental benefits of these technologies is essential for aligning the sector with national and global sustainability goals. Future research should incorporate a wider variety of stakeholders and geographic regions to enhance the generalizability of the findings.

Keywords: Sustainability, Environmental Technologies, construction sector, Technology Adoption, Ghana.

1. Introduction

Ghana's rapid urbanisation, particularly in cities like Accra, Kumasi, and Takoradi, has significantly increased housing demand due to rising migration into these urban areas. As the most populous cities in the country, they have experienced heightened requirements for both residential and commercial spaces, creating dynamic opportunities in the construction sector. Investment avenues in Ghana's construction market include residential property development, Real Estate Investment Trusts (REITs), and land flipping (Ghana Investment Promotion Centre, 2020). Prominent developers offer investment options like buy-to-let properties, direct ownership, and leveraged ownership, providing diverse opportunities for portfolio diversification. Despite these opportunities, financing remains a critical challenge. Commercial banks, private equity funds, and pension funds are among the primary sources of construction project financing. However, commercial banks often mandate upfront contributions of up to 30% of a project's value, creating barriers for many developers (Ghana Investment Promotion Centre, 2020). To address these challenges, government interventions like the National Housing Policy, affordable housing initiatives, and land title registration reforms aim to mitigate the housing deficit and promote growth. While the sector continues to expand, its environmental impact cannot be overlooked. This study investigates the key drivers influencing the adoption of sustainable

environmental technologies in Ghana's construction industry, emphasising strategies to balance economic growth with environmental sustainability.

2. Literature Review

Environmental management has gained prominence in the construction industry due to its critical role in addressing environmental degradation. Like many developing countries, Ghana is experiencing rapid urbanisation, which has led to a significant increase in construction activities, exacerbating environmental challenges. The construction industry's contribution to environmental degradation necessitates the integration of sustainable environmental practices (Office for National Statistics, 2018). This review examines the key drivers influencing the adoption of sustainable environmental technologies in Ghana's construction sector:

2.1. Regulatory Frameworks

Environmental regulations serve as a primary driver for sustainable practices, according to Darko and Chan (2018). In Ghana, the Environmental Protection Agency (EPA) enforces the Environmental Assessment Regulations, requiring developers to conduct Environmental Impact Assessments (EIA) before initiating construction projects. (Environmental Protection Agency, Ghana, n.d.). Regulatory measures include mandatory reporting of energy usage, adherence to building codes, and compliance with

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carbon emissions standards (Iwaro and Mwasha, 2010). These regulations promote eco-innovations by encouraging the adoption of energy-efficient materials, waste reduction techniques, and resource optimisation. Furthermore, compliance with environmental regulations can enhance efficiency and reduce costs associated with material handling, energy consumption, and waste disposal (Iwaro and Mwasha, 2010).

2.2. Financial Incentives

Incorporating sustainable practices can result in significant cost savings over time. For example, using energy-efficient HVAC systems, lighting, and sustainable building materials reduces operational costs while enhancing the longevity of structures (Ekung *et al.*, 2022). Effective cost management is critical in achieving sustainable construction, requiring accurate estimation, cost control, and efficient financial planning. Proper risk assessment and feasibility studies are essential for minimising project costs and maximising environmental benefits (El-Sayegh *et al.*, 2018).

2.3. Corporate Social Responsibility (CSR) and Tenant Demand

Construction companies in Ghana are increasingly integrating environmental sustainability into their CSR policies to enhance their reputation and fulfil stakeholder expectations. Meeting CSR goals improves public perception and drives the adoption of eco-friendly technologies. Lawluy *et al.* (2022) emphasise that CSR-driven environmental practices help organisations align with global sustainability standards. Consumer preferences play a pivotal role in driving sustainable development. Environmentally conscious tenants prefer buildings that incorporate green technologies, such as energy-efficient designs and sustainable materials and are often willing to pay a premium for these features (Lawluy *et al.*, 2022). Developers aiming to meet these demands must focus on ergonomic designs, environmental friendliness, and functional spaces to enhance tenant satisfaction.

2.4. Competitive Advantage and Investor Pressure

Adopting sustainable practices provides construction companies with a competitive edge. Differentiation through green technologies attracts investors and environmentally conscious clients, boosting market performance (Chininga *et al.*, 2024). Investors are increasingly prioritising Environmental, Social, and Governance (ESG) criteria. Institutional investors demand sustainable practices from construction companies, linking these practices to long-term profitability. Additionally, developers who incorporate sustainable technologies often find it easier to access financing, as financial institutions are more inclined to fund projects with clear environmental benefits (Darko and Chan., 2018).

2.5. Technological Innovations

Technological advancements are key drivers of sustainability in real estate. These include energy-efficient systems, water conservation technologies, and renewable energy integration. For example, the adoption of solar water heating, rainwater harvesting, and greywater recycling systems enhances environmental performance. Innovations in HVAC systems, lighting technologies, and building envelope designs also contribute significantly to reducing greenhouse gas emissions and improving indoor environmental quality (Darko and Chan, 2018).

2.6. Stakeholder Engagement

The role of the construction team is critical in promoting sustainable practices. Key factors include effective project management, team integration, and innovative design processes (El-Sayegh *et al.*, 2018). Contractors who incorporate written environmental policies, organise training programs, and conduct environmental audits contribute significantly to the success of sustainable projects (Iwaro and Mwasha, 2010). Engaging stakeholders such as government authorities, investors, and community members fosters collaboration and ensures that environmental concerns are addressed effectively. Stakeholder pressures, including those from environmental groups and trade associations, compel developers to adopt best practices (Wu *et al.*, 2023).

2.7. Market Demand and Social Norms

The increasing market demand for sustainable buildings reflects a shift in consumer preferences toward eco-friendly products. Social norms also play a vital role, as public awareness and education campaigns can influence behaviour and attitudes toward green technologies (El-Sayegh *et al.*, 2018).

Despite the evident drivers, challenges such as high initial costs, limited market awareness, and insufficient policy enforcement hinder the adoption of sustainable technologies. Addressing these challenges requires targeted interventions, including policy incentives, public education, and capacity-building initiatives (Yeboah, 2024). Regulatory frameworks, cost considerations, CSR, consumer demand, and technological advancements influence the adoption of sustainable environmental technologies in Ghana's construction sector. By addressing barriers and leveraging these drivers, stakeholders can create a more sustainable construction industry that aligns with global environmental goals.

3. Research Methodology

This study adopts a quantitative methodology to explore the factors driving the adoption of sustainable environmental technologies within Ghana's construction sector. A structured survey was designed and administered to professionals across key

stakeholder groups. The sample size was determined using Yamane's (1967) formula for finite populations. To ensure a representative sample, the sample size was determined using Yamane's 1967 formula for finite populations:

$$n = \frac{N}{\{1 + Ne^2\}}$$

where n is the sample size, N is the total population, and e is the margin of error (set at 5% or 0.05 for a 95% confidence level). Applying this formula, the estimated sample sizes were 154 for the Ghana Real Estate Developers Association, 220 for the Ghana Institution of Engineering, 305 for the Institution of Engineering and Technology, and 243 for the Architects Registration Council. However, despite these estimates, only 275 responses were received and analysed, representing the final sample size for the study. While the response rate was lower than initially anticipated, it aligns with acceptable standards in survey research (Baruch & Holtom, 2008) and remains sufficient for statistical analysis. To address potential non-response bias, follow-ups were conducted via email and telephone reminders. Additionally, a wave analysis was performed, comparing early and late respondents across key variables. No significant differences were detected, suggesting minimal bias in the dataset. The instrument's reliability was assessed using Cronbach's alpha and Composite Reliability (CR). All constructs exhibited Cronbach's alpha values above 0.70 and CR values exceeding 0.80, confirming internal consistency. Convergent validity was established through Average Variance Extracted (AVE) values above 0.50. Ethical principles were strictly followed, ensuring informed consent, confidentiality, and anonymisation of data. Permissions were obtained from relevant professional associations to maintain research integrity (Kara, 2019; Polit and Beck, 2006).

The demographic profile of respondents reflected gender diversity (53.45% male, 46.55% female) and age variation (ranging from under 25 to over 55), ensuring a balanced representation of professionals across different experience levels. To examine relationships between factors influencing sustainable technology adoption, Spearman's correlation coefficient (ρ) was applied due to the dataset not meeting normality assumptions, ensuring robust statistical interpretation. Spearman's correlation is appropriate for measuring the strength and direction of monotonic relationships between variables, even when data distributions are non-normal (Kumar, 2019).

4. Findings and Discussions

Environmental management has become increasingly critical in Ghana's construction sector, where rapid urbanisation necessitates sustainable practices. Table 1 (see Appendix 1) presents the key drivers influencing environmental management, supported by mean scores,

standard deviations, and responses from 275 participants.

The findings indicate strong agreement among respondents on the key drivers of environmental management in the construction sector. Among the most significant factors is the emphasis on energy efficiency, waste management, and greenhouse gas reduction, which received the highest mean score (4.5) with low variability ($SD = 0.5$). This highlights a strong consensus on the importance of environmental considerations in improving sustainability. Government interventions play a critical role in promoting environmental sustainability. Government support for research and development in sustainable construction technologies also received a high mean score (4.5), emphasising the importance of innovation in driving sustainability. These findings align with prior studies (Zhang *et al.*, 2020), reinforcing the need for government-led support mechanisms.

Additionally, environmental regulations and sustainable building certifications (e.g., EDGE, LEED, BREEAM) emerged as key enablers (mean = 4.4), reinforcing the importance of formal policies in guiding eco-friendly practices. Market forces significantly influence environmental management decisions. Technological advancements and market demand for sustainable construction (mean = 4.4) highlight the role of innovation and consumer awareness in driving sustainability. Similarly, consumer demand for green buildings (mean = 4.3) underscores the influence of public preferences on corporate environmental strategies. The findings also emphasise the importance of skilled professionals and financial resources in achieving sustainability goals. Employee competency and financial capacity (mean = 4.3) were identified as crucial enablers of environmental sustainability. Additionally, stakeholder awareness and education programs (mean = 4.4) demonstrate the need to actively engage key industry players. Collaboration among industry professionals, including networking and partnerships with environmental organisations (mean = 4.2–4.3), highlights the importance of collective action. Financial incentives also play a role in adoption, with financial support for sustainability initiatives scoring a mean of 4.1. The potential for cross-sectoral learning is evident, with access to product and process innovation (mean = 4.1, $SD = 0.7$) indicating a moderate level of importance. Similarly, learning from other industries (mean = 4.1, $SD = 0.7$) suggests an opportunity to leverage best practices from different sectors to improve environmental performance.

4.1. Correlation Analysis

This section presents the correlation analysis results. The correlation analysis examines the relationships between key factors influencing the adoption of sustainable Environmental Construction Technologies (ECTs) in Ghana's real estate industry. As the dataset did not meet the normality assumption, Spearman's

correlation was used instead of Pearson's correlation to examine the relationships among key factors influencing the adoption of Environmental Construction Technologies (ECTs) in Ghana's real estate industry (Table 2).

4.1.2. Financial Incentives and Economic Drivers
A moderate correlation between financial incentives and technological advancements ($r = 0.521$, $p < 0.01$) highlights the influence of financial mechanisms—such as subsidies, tax incentives, and green financing

Table 2: Correlation Matrix of Key Enablers for ECT Adoption
(Spearman's correlation coefficients, $n = 100$)

Variables	1. Energy Efficiency	2. Financial Incentives	3. Technological Advancements	4. Regulatory Policies	5. Stakeholder Engagement
1. Energy Efficiency	1.000	0.582**	0.431**	0.678**	0.590**
2. Financial Incentives	0.582**	1.000	0.521**	0.612**	0.456**
3. Technological Advancements	0.431**	0.521**	1.000	0.489**	0.533**
4. Regulatory Policies	0.678**	0.612**	0.489**	1.000	0.617**
5. Stakeholder Engagement	0.590**	0.456**	0.533**	0.617**	1.000

Notes: Spearman's correlation coefficients reported.

Significance levels: $p < 0.01$ (coefficients with double asterisks indicate significant correlation).

The results indicate strong positive correlations among key enablers of ECT adoption in Ghana's real estate industry. This next section discusses four Key Constructs, namely: Regulatory Policies and Stakeholder Engagement, Financial Incentives and Economic Drivers, Technological Advancements and Market Demand, Stakeholder Engagement and Corporate Social Responsibility (CSR) that are necessary in adopting eco-friendly construction technologies in the construction industry:

4.1.1. Regulatory Policies and Stakeholder Engagement

Spearman's correlation analysis revealed significant relationships among key enablers of ECT adoption. Energy efficiency showed a strong correlation with regulatory policies ($\rho = 0.678$, $p < 0.01$), indicating the influence of government intervention. Financial incentives were moderately correlated with technological advancements ($\rho = 0.521$, $p < 0.01$), suggesting that financial support plays a key role in innovation adoption. Stricter building codes, mandatory green certifications (e.g., EDGE, LEED, and BREEAM), and compliance monitoring have significantly influenced the integration of energy-efficient technologies. Similar studies confirm that well-enforced policies lead to widespread adoption of sustainable practices (Darko & Chan, 2018). Furthermore, the positive correlation between stakeholder engagement and regulatory policies ($r = 0.617$, $p < 0.01$) underscores the importance of multi-stakeholder collaboration. Effective public-private partnerships (PPPs), industry regulations, and government incentives strengthen policy implementation. Engaging financial institutions, environmental agencies, and real estate stakeholders ensures that sustainability policies are practical, enforceable, and widely accepted (Wang and Ma, 2021).

programs—on sustainability innovation. These incentives reduce investment risks, making it easier for developers to adopt eco-friendly construction technologies (Dzokoto *et al.*, 2014). Additionally, financial incentives align with market demand for green buildings, driving developers to prioritise energy efficiency, natural ventilation, and water conservation systems (Guribie *et al.*, 2021). As consumer preferences shift toward sustainable housing, developers increasingly integrate smart building solutions and resource-efficient materials to maintain competitiveness. This confirms the role of financial policies in accelerating the transition to sustainable real estate.

4.1.3. Technological Advancements and Market Demand

While no direct correlation was observed between technological advancements and market demand, the findings indicate an indirect relationship through financial incentives and policy interventions. Modern energy-efficient technologies, renewable energy systems, and smart building solutions are reshaping Ghana's construction sector, aligning with global Fourth Industrial Revolution (4IR) trends (Dzokoto *et al.*, 2014). The positive correlation between financial incentives and technological innovation ($r = 0.521$, $p < 0.01$) suggests that government support and investment in R&D drive green construction technologies. As consumers increasingly demand eco-friendly real estate, developers are leveraging advancements in construction automation, smart energy management, and carbon-neutral building materials. This trend reinforces the need for continuous investment in sustainable technology to meet market expectations.

4.1.4. Stakeholder Engagement and Corporate Social Responsibility (CSR)

Stakeholder engagement plays a pivotal role in shaping sustainability policies and industry-wide environmental practices. The strong correlation between stakeholder engagement and regulatory policies ($r = 0.617$, $p < 0.01$) supports the view that government, investors, developers, and environmental organisations must collaborate to achieve sustainability goals. Corporate Social Responsibility (CSR) has also emerged as a key driver of stakeholder engagement in ECT adoption. Although not explicitly tested in this study, prior research highlights that real estate firms are increasingly integrating sustainability goals into CSR strategies (Ojo & Ogunsemi, 2019). Many companies implement carbon footprint reduction programs, energy-efficient building initiatives, and resource conservation strategies, strengthening partnerships with government regulators, financial institutions, and community stakeholders. These efforts enhance the adoption of sustainable construction technologies, reinforcing the broader sustainability agenda in Ghana's real estate sector.

5. Conclusions and Further Research

This study highlights regulatory frameworks, financial incentives, technological innovation, and stakeholder collaboration as key enablers of environmental sustainability in Ghana's real estate sector. Strengthening policies on emissions control, renewable energy, and waste management will enhance green

building adoption. Financial mechanisms such as tax breaks, subsidies, and green financing promote sustainable investments while growing consumer demand encourages developers to integrate energy-efficient designs and smart technologies. Technological advancements, including smart building solutions and renewable energy systems, further drive sustainability. Private sector participation and CSR initiatives are crucial for aligning with global best practices. Collaboration among policymakers, financial institutions, and industry stakeholders fosters policy development and reinforces sustainability commitments. To achieve lasting progress, regulatory enforcement must be strengthened, developers should leverage financial incentives, and public awareness campaigns should promote eco-friendly real estate. Future research should explore long-term policy impacts and technological advancements to ensure sustained environmental progress.

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Appendix 1

Table 1: Descriptive Statistics on Key Drivers towards Environmental Management in the Construction Sector in Ghana:

Statements	Mean	Standard Deviation	N
Selecting the right construction team is vital in enhancing environmental performance.	4.2	0.6	275
Environmental issues such as energy efficiency, waste management, and greenhouse gas reduction are important considerations.	4.5	0.5	275
The organisation's access to product innovation and process innovation improves environmental performance.	4.1	0.7	275
Corporate social responsibility initiatives motivate construction companies to implement environmental management practices.	4.3	0.6	275
Environmental regulations imposed by the government encourage the adoption of eco-friendly practices.	4.4	0.5	275
External stakeholders, such as government authorities and society, have a significant level of influence and decision-making in the development of the construction industry.	4.2	0.6	275
Government support and funding for research and development of sustainable construction technologies would significantly encourage their adoption of environmental sustainability practices.	4.5	0.5	275
Factors like employee competency and financial resources would significantly impact environmental sustainability in the industry.	4.3	0.6	275
The availability of financial incentives would encourage construction companies to adopt environmentally friendly practices.	4.1	0.7	275
Market demand and technological advancements drive the adoption of sustainable practices in the construction industry.	4.4	0.5	275
Consumer demand for sustainable buildings drives construction companies to prioritise environmental management practices.	4.3	0.6	275
Social factors, such as public awareness and promotion of health and safety, would significantly influence environmental practices in real estate.	4.2	0.6	275
The construction industry can learn from the environmental practices implemented in other industries.	4.1	0.7	275
Networking and collaboration among different professionals would enhance key stakeholder experiences to contribute to good environmental management practices.	4.3	0.6	275
Integrating sustainable building materials and technologies would enhance the market competitiveness of construction projects in Ghana.	4.5	0.5	275
Sustainable building certifications (e.g., EDGE, LEED, and BREEAM) are considered key drivers for construction companies to pursue environmentally friendly practices.	4.4	0.5	275
Collaborative partnerships with environmental organisations promote the adoption of sustainable practices in the construction industry.	4.2	0.6	275
Industry recognition and awards for environmental management practices would motivate construction companies to strive for sustainability practices.	4.3	0.6	275
Employee and stakeholder awareness and education programs on sustainability would promote the implementation of environmental management practices among construction stakeholders.	4.4	0.5	275
Overall	4.3	0.58	275

Min =1, Max = 5

Source: Authors's computations, SPSS 22.