

Corporate Sustainability and Green Technology Cost-Benefit Analysis: Ghanaian's Perspectives

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Abstract

This study examines the adoption of green technologies and corporate sustainability practices among Ghanaian enterprises, highlighting the crucial role of cost-benefit analysis in promoting environmentally sustainable business operations. In the 21st century, businesses worldwide face growing pressure to reduce their environmental footprint. However, in Ghana, the absence of accurate and context-specific cost-benefit analysis tools poses a significant barrier to effectively evaluating and implementing green technologies.

The research aims to identify gaps in existing cost-benefit analysis methodologies within Ghanaian enterprises and assess how these gaps hinder the adoption of sustainable practices. It further explores the potential benefits of developing and introducing tailored cost-benefit analysis tools designed for the Ghanaian context, which could drive the transition toward a sustainable economy.

Using a mixed-methods approach, the study combines surveys and interviews to collect data from a diverse sample of 150 enterprises across various sectors in Ghana. The survey data provides quantitative insights into the challenges and opportunities associated with green technology adoption, while the interviews offer qualitative perspectives on the importance of sustainability and the critical role of cost-benefit analysis.

The findings reveal a significant lack of comprehensive cost-benefit analysis tools, which limits Ghanaian enterprises' ability to fully embrace green technologies. Traditional economic models, focused on short-term financial gains, often neglect the long-term benefits of sustainability, thereby slowing progress toward a green economy. The study also highlights the influence of environmental initiatives, stakeholder engagement, and regulatory frameworks on corporate sustainability. Importantly, the introduction of a tailored cost-benefit analysis tool could serve as a catalyst for overcoming these barriers, strengthening the case for long-term sustainability and the adoption of environmentally friendly technologies in Ghana.

This research underscores the urgent need for a robust and context-specific cost-benefit analysis framework to promote the widespread adoption of green technologies in Ghana, ultimately contributing to national and global sustainability goals.

Keywords: Green Technology; Corporate Sustainability; Ghana Economy; Cost-benefit analysis

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1. Introduction

Every company's expertise is built on its growth path. In their context, organizations interact, change, and impact the environment. Corporations affect macroeconomic, ecological, and social conditions by being proactive. Consumers and other stakeholders want to maximize their usefulness, and corporations seek the optimal labor-money mix (Pfajfar et al., 2022). Businesses impact changing market conditions in various ways. Sustainable growth requires enterprises to improve living conditions without harming future generations. Ghana has no formal corporate sustainability legislation, but several policies, regulations, practices, and initiatives provide the framework (Sarpong, n.d.; Silk et al., n.d.). Corporate Social Responsibility (CSR) in Ghana is regulated by legislation and various frameworks (Adomako & Tran, 2022). This study examines Ghana's social engagement and financial resources and explores a large amount of conceptual framework CSR literature for developing economies. The "Institution Difference Hypothesis" provided continuous theoretical grounds for this research. The Initiatief Duurzame Handel (IDH) shows how institutional differences between industrialized and developing countries will impact CSR approach, generation, and outcomes (Langford, 2019).

Global corporate responsibility has expanded amid arguments over whether corporations should move from influencing economic results to proactively addressing complex social challenges. The community, customers, and others have demanded implicated business behavior, policies, initiatives, and transparency (Javeed & Lefen, 2019). Many companies believe that "doing good" adds up and may win over stakeholders. Modern energy balance and carbon management approaches include green buildings, which enhance living circumstances and decrease environmental impact. Green economic indicator, houses save 185 KWh/m² of heat and electricity and release less carbon dioxide than concrete (Wu et al., 2022). Green buildings increase tenants' quality of life, enhancing stakeholder engagement. Despite its eco-friendly products and concept, sustainable infrastructure has failed to stimulate economic growth.

Green building buyers stress additional expenditures, which is crucial to project strategy. Green technology, eco materials, and inventive techniques to fulfill energy-saving green construction rules raise costs in many future projects. (Opoku et al., 2019) opine that some researchers classify extra expenses as technical, managerial, and regulatory. Technical expenses for green construction include environmental and cutting-edge designs, while administrative costs include environmental rules and experimental operations. Green standards certification costs are included (Agyekum et al., 2019). Due to large and unpredictable costs, property developers are skeptical of green technologies. Green technology delivers incremental advantages over traditional structures (mean society) (Agyekum et al., 2019). Manufacturing technology boosts industrial growth. Green buildings add energy savings and environmental advantages. Green construction benefits include energy efficiency, garbage management, and inventive product use, which may save money immediately (U.S. Green Building Council (2021)). Green buildings stabilize CO₂, decrease pollutants, and reduce greenhouse gas emissions. Green technology offers advantages and expenses, but investors worry about its latency and uneven value. Thus, the property sector's adoption of sustainable technology requires an accurate cost assessment (Zhang et al., 2011). Green innovation helps companies create eco-friendly products for SD. Firms must improve organizationally and technically. Green technology and supply chain management inspiration (GMI) are two types of green innovation. GTI uses technology to protect the environment. GTI enables organizations to save resources, enhance operations, and balance environmental, economic, and manufacturing factors (Abbas & Sağsan, 2019). To enhance environmental, administrative, and industrial processes, GMI enterprises reorganize or change management. Due to heavy debt, lack of energy, emigration of technical talent, food shortages, and dwindling tourist money, Caribbean politicians desire a sustainable economic strategy. Green technologies, clean industries, ecological production and consumption, alternative and renewable energies, and environmental stewardship make sense for development.

Despite embracing sustainable future language, regional leaders say they should set the direction, not multinational banks and nonprofits (Shah et al., 2016). Ghana, not only in Africa, needs robust corporate governance. This principle covers Federation corporate companies' efficiency, profits, and ability to generate income and employment; Confederation countries' long-term competitiveness in the global industry; Commonwealth financial industries' stability and international standing; and the relationship between corporate businesses in an economic system and that country (Agyemang et al., 2020).

These are the industry's fastest-growing and most profitable sectors. Green business methods and technologies are becoming critical for 21st-century organizations. Ghanaian companies lack cost-benefit analysis frameworks to assess the economic sustainability of sustainable business practices and green technologies.

An interesting and important research thread is the search for an answer to the question of how contemporary Ghanaian companies lack CBA models to leapfrog their challenges to more sustainable development practices, considering the growing pressure to conduct activities in harmony with the environment.

Chomać-Pierzecka, (2023) asserts that the recipe of creating a bundle of values and strengthening competitiveness the idea of sustainable development enforces a strong desire for an information supply that, through access to up-to-date knowledge, will raise the level of decision-making processes, determining the higher appropriateness of economic decisions. The above justifies the need for an overview of contemporary business challenges in the light of sustainable development and an assessment of the direction of the challenges taken and the level of adaptation of the business models of enterprises, to achieve economic and socio-environmental goals in connection with their activities (Chomać-Pierzecka, 2023).

Sustainability and green technology adoption studies mainly concentrate on developed nations, and cost-benefit analysis models in Ghana are few. Thus, Ghanaian businesses need a detailed cost-benefit analysis to evaluate sustainable business practices and green technologies and identify their challenges and enablers.

Hence, this study aims to design a comprehensive cost-benefit analysis tool to analyze the feasibility of adopting green technology and sustainable business practices in Ghanaian enterprises, identify obstacles and drivers, and promote their implementations. We intend to identify the costs, benefits, and advantages of green technology and its effects on sustainable business practices for Ghanaian enterprises and what will influence its full adoption.

1.1. Hypothesis

Hypothesis 1 (H1): Ghanaian enterprises that use green technology and sustainable business practices save money and the environment over time.

Hypothesis 2 (H2): High initial expenses and lack of knowledge prevent Ghanaian enterprises from adopting green technology and sustainable business practices.

Hypothesis 3 (H3): Stakeholder-connected and environmentally conscious firms are more likely to embrace green technology and sustainable practices.

This study will build a rigorous cost-benefit analysis model to help Ghanaian companies pick sustainable business strategies and green technologies. Ghanaian policymakers may use the model to design effective incentives and policies to support sustainable business and green technologies. The findings will encourage other developing countries to adopt green technologies and sustainable economic practices.

2. Related Works

A vibrant construction industry in a developing market that mobilizes labour and local resources to build and maintain houses, buildings, and basic equipment may boost industrial expansion and job creation. Ghana has 35 million people and is one of West Africa's fastest-growing economies (World Bank, 2023). A simple Granger causality test used 1968 - 2004 time series data. Consider one of Ghana's primary industrial drivers (Abubakar et al., 2018). The natural science in GEO-6 shows that if civilizations continue their development patterns, various negative human repercussions, including possibly substantial health implications, are likely. This leads to the mistaken belief that significant emissions objectives are costly and should be delayed until new, cheap environmental solutions are found. Researchers say this contradicts the facts and delays decarbonization, increasing expenses. Decision-makers considering responding to professional sciences' increasingly dire warnings about the ecosystem should recognize the procedures that encourage advancement, modify social standards, and avoid blocking CO₂ and resource-intensive technology solutions, facilities, and habits.

Green roofs greatly enhance urban sustainability. This strategy is not being implemented swiftly in many developing countries due to a lack of local research (Orozco C. R., 2021). This study evaluates Philippine green roof systems for sustainability and cost-benefit to encourage adoption. Most rooftop gardens in the survey met minimum criteria, although efficiency may provide extra benefits. Concrete roofs with green coverings cost extra. All but one green roof system satisfied retention standards. Many green roofing solutions have significant pricing differences. For broad and intensive rooftop gardens, the lowest repair cost matches the lowest construction cost. Though more expensive than construction, restoring concrete roofs is cheaper than green structures. Roofs and other low-impact methods face significant initial investment barriers in the Philippines (Orozco C. R., 2021).

Company sustainability practices and firm financial success have been extensively studied in wealthier countries but less in poor countries (Manrique & Martí-Ballester, 2017). The primary purpose of Manrique et. al., (2017) was to examine how a company's responsibility efficiency influences its financial efficiency during a financial crisis in

connection to the nation's economic growth. They collected data on 2982 large firms from 2014 to 2023. The researchers rectify the systematic deviation for business and year-specific clustering using Petersen's approach. The data showed that environmental policies boost company profitability in developed and developing countries. Some limitations apply to this study. First, the analyzed time range coincided with the global economy's turmoil; future research should encompass the recession. Second, this research does not examine the location of company affiliates, which may affect the connection under consideration. However, affiliates may affect business size. A corporation with two affiliates is much smaller than one with 10. The number of corporate affiliates might replace firm size. Each item is used as a size proxy in the previous study. We used one-year lag causal variables to mitigate endogeneity in the framework. Fourthly, our system for evaluating corporate social and environmental success relies on a robust and well-maintained score, but its application and evaluation may be limited. The results cannot be applied to small and medium-sized firms since this research only addressed big organizations. To better understand results, future research should incorporate diverse business sizes in their sample (Manrique et al., 2017).

Lack of capital limits supplemental security income technologies like solar-powered cooling systems. Farmers now use cheap technologies, such as ordinary watering cans, which provide low returns. Access to credit or other funding may reduce capital constraints and boost smallholders' profits from market-driven, high-value agricultural manufacturing (Balana et al., 2020).

2.1. Theories Backing Cost-Benefit Analysis

Policy efficiency assessments were applied using longstanding fundamentality cost-benefit analysis methods in economics, which are extensively utilized for various projects. This analytical approach seeks out decisions' overall costs and benefits, meaning that decision entities' pros and cons can be weighed quantitatively. Cost-benefit is conceptualized into a broader field, welfare economics, aimed at raising societal good via various policy decisions (Boardman, 2018). By making the associated costs and benefits numerical, policymakers garner essential insights that enable choices to heighten society's overall good. Nonetheless, the foundations of cost-benefit analysis continually faced debates, evolving differentiated theories for varied context applications (Sunstein, 2021).

Classical Economic Theory

Consideration of economic theory classically presents denials of simplicity in applications and costs resulting in contractual exchanges. Contrastingly, the reliance theory proposes stark divergence, constraining aforementioned freedoms expansively to account for reliance detriments absent formal agreement structures (Atiyah, 1986). This theoretical bifurcation elicits protracted deliberations on obligatory contract natures pressing within economic and juridical perceptions. Applications in academia contextually, such as bisphosphonate remedy evaluations for malignancies, elucidate reflections on economic cost efficiency, which results in healthcare deducements (Russell et al., 2021). These theories, appraised conjointly with empirically derived findings, imbue complete cognizance of classical economics' applications in intricate cost-benefit derivations, proffering insightful discernment for hypothetical decision frameworks across domains.

2.2. Behavioural Economics Perspective

As mentioned in Aber et al. (2017), public policies increasingly recognize the significance of aiming for early childhood development services. However, they are confronted with ongoing troubles about low use and stick rates. As interventions attempt to resolve structural and psycho-social obstacles to parent engagement, there must be a bigger focus on the decision-making roles of parents, drawing from behavioral sciences. As noted by Aber et al. (2017), this angle on how parents behave in developmental contexts can guide how to design interventions to boost the effects of early development programs. Also, looking from a behavioral economics angle, improving productivity in programs such as irrigation means grasping water use efficiency and irrigation efficiency. By combining ideas from behavioral economics with early childhood development programs, those who make policies can better the cost-benefit analysis of interventions and make results better for kids and their families.

2.3. Environmental Economics Framework

Inquiries about the assimilation of open-source software within corporate Management Information System (MIS) organizations (Dedrick et al., 2004) elucidate the evaluative methodologies concerning software assimilation. Deciphering said assimilation paradigms proves pivotal in architecting an encompassing environmental economics schema, given technology's substantial contribution towards formulating environment-centric directives and maneuvers. Through juxtaposing antecedent scholastic and mainstream expositions on the assimilation of open-source software with perceptions from MIS authorities, an empirically substantiated theory may be developed to guide the

incorporation of open-source infrastructures into environmental economic paradigms. Within this schema, it can bolster comprehension of the fiscal ramifications tied to ecological preservation stratagems. This holistic methodology might illuminate the cost-benefit analysis requisite to gauge the economic tenability of ecological policies and interventions, thus fostering more enduring decision-making protocols.

The theories buttress cost-benefit analysis, conferring a substantial framework for deciding in disparate domains encompassing economics, public policy, and ecological stewardship. Moreover, behavioral economics elucidates individual deviations from rational decision-making, altering cost-benefit analysis outcomes. Despite varying suppositions and techniques, these theories bestow policymakers and academics with invaluable insights and mechanisms for informed decision-making, maximizing societal welfare. By amalgamating these heterogeneous viewpoints, subsequent research might refine cost-benefit analysis methodologies and elevate their pertinence in real-world decision-making milieus.

2.4. Green Technology

The concept of sustainability in economic growth is widely recognized. The World Commission on Environment and Development (WCED) introduced the idea of a sustainable economy in 1987, defining it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Leal et al., 2020). This idea is anchored in three fundamental aspects—environmental sustainability, economic sustainability, and social sustainability—often referred to as the triple bottom line or the three pillars of a green economy (Purvis et al., 2021). Achieving sustainable human development while minimizing environmental impact is a complex challenge. Renewable energy plays a crucial role by adhering to three fundamental principles: green marketing, conserving natural resources, and promoting the generation and use of sustainable energy sources. The green construction model stresses the importance of maintaining the vitality of ecological life-support systems—such as freshwater, soil, and air—to ensure the sustainability of ecosystems (Darko et al., 2020). Although the goals of a green economy are consistent, the strategies to achieve it can vary based on the country, region, or sector involved. The cornerstone of sustainable development lies in boosting economic productivity, competitiveness, and prosperity to foster growth. From a sociological and regulatory perspective, green building initiatives focus on enhancing human welfare, security, prosperity, recreational value, living standards, equality, social cohesion, and cultural preservation (Jones et al., 2022). Researchers have noted that these three pillars of green manufacturing often overlap, and for long-term sustainable growth, development efforts must integrate economic, social, and environmental considerations.

2.5. Empirical Understanding

Ghana has little empirical research on business sustainability and green technology cost-benefit analysis. Some studies reveal the economic viability and advantages of sustainable business practices and green technology in Ghana. Boateng et al. (2018) examined the financial performance of Ghana Stock Exchange (GSE) entities that declared sustainable practices. The research indicated that businesses that reported sustainability practices had a better Return on Equity (ROE). Sustainability initiatives may improve a firm's financial success. Another research study by Ansong and Domfeh (2021) studied the uptake of renewable energy in Ghanaian SMEs. According to the report, renewable energy adoption was driven by projected cost savings, energy independence, and environmental advantages. The research also found that adoption difficulties include high upfront expenditures, lack of finance, and poor legislative support. Korankye and Opoku (2019) examined Ghana's sustainable building hurdles and facilitators. According to the report, lack of knowledge and education, high prices, and regulatory enforcement were the biggest challenges to sustainable building. Government incentives, customer demand, and technology drove sustainable building techniques. These studies demonstrate Ghana's pros and cons of sustainable business practices and green technology. More studies on these practices and technologies' cost-benefit analysis are needed to establish a complete model for corporate sustainability and green technology in Ghana's economy.

3. Methodology

Ghana's richness and poverty have fluctuated since its 1957 independence (Aboagye Y. P, 2020). The writer opined that the social and economic framework in which sustainability has been sought lately must be reviewed since nature was a fundamental component of these macro-developments. This is done for financial restructuring (Sarfo et al., 2024). The paper analyzes business sustainability and green technologies in the 21st century from 2014 to 2023 using cost-benefit analysis and focuses on Ghana. This study will employ mixed methods to analyze quantitative and qualitative data.

3.1. Data Collection

The study collected quantitative data from the Ghana statistical service on data collated on Ghanaian corporate firms on their current business practices, expenses, and benefits associated with implementing sustainable business practices, green technology, and the barriers and enablers of adoption (Ghana Statistical Service, 2023). Acquiring a summary of the financial records of companies to examine long-term cost savings and economic advantages using the information provided by the Ghana Statistical Board (<https://microdata.statsghana.gov.gh/index.php/catalog/119>). Data was collected from government official websites, industry experts, and academics to acquire qualitative data on the institutional, cultural, and environmental aspects that impact sustainable business practices and green technology. Several entities, such as enterprises, organizations, agriculture, and market sectors determine the economy's corporate sustainability. The current study is on agriculture and mining, with a specific emphasis on using bio-gas technology as a kind of green technology from 2000 to 2023. The cost-benefit model evaluation procedure.

Compare the means of cost savings and environmental benefits across multiple groups categorized by different levels of adoption or other influencing factors as shown in equation (1) to equation (8).

$$MS_{between} = \frac{MS_{bwithin}}{MS_{bwithin}} \quad (1)$$

Where:

$MS_{between}$ = Mean square between groups.

MS_{within} = Mean square within groups.

$$MS_{between} = \frac{df_{between}}{S_{between}} \quad (2)$$

$$MS_{between} = \frac{df_{within}}{S_{within}} \quad (3)$$

Where:

$S_{between}$ = Sum of squares between groups.

S_{within} = Sum of squares within groups.

$df_{between}$ = Degrees of freedom between groups.

df_{within} = Degrees of freedom within groups.

3.2. Regression Analysis

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon \quad (4)$$

Where:

Y = Dependent variable (e.g., cost savings, environmental benefits).

β_0 = Intercept.

$\beta_1, \beta_2, \beta_3$ = Regression coefficients for independent variables.

X_1, X_2, X_3 = Independent variables

ϵ = Error term.

3.3. Principles

Building a cost-benefit analysis model for sustainability and green technology adoption involves identifying key elements that will affect the study (Duah et al., 2025b). Adopting sustainable business practices and green technology may include costs, rewards, risks, and uncertainties.

Assessment of Costs and Benefits: Next, measure the costs and advantages of sustainable business practices and green technology. Quantify adoption's financial, social, and environmental benefits. When comparing adoption costs and benefits across time, it is vital to discount future costs and benefits to their present value. This enables meaningful cost-benefit comparisons throughout time.

Analysis of Sensitivity: Sensitivity analysis evaluates the robustness of the cost-benefit analysis model. This includes changing model inputs to assess how responsive outcomes are to input changes. Evaluates the costs and advantages of adopting sustainable business practices and green technology to those of alternative business practices. This comparison helps determine the most cost-effective and sustainable alternative.

A thorough cost-benefit analysis model for sustainability and green technology adoption in Ghana's economy should incorporate financial, social, and environmental implications and give a complete decision-making framework.

4. Results and discussion

4.1. Corporate sustainability

Several studies have examined how much modern research differs from mid-21st-century research (Fortunato et al, 2018). The empirical studies suggest that the original study focused on sustainability principles, their ramifications, and what motivates firms to provide sustainability information. Newer research has examined what drives sustainability reporting and how firm success affects sustainable development disclosures (Julian & Ofori-Dankwa 2013). The result showed great integrated reporting and lower capital costs. This shows how sustainability reports increase data dependability and monitoring. After controlling for nation-level factors, including regulatory conditions and public awareness, a similar research study with a population from other nations yielded similar results. Capital cost was negatively correlated with non-financial statements, including ecological and social disclosures (Akinbobola, 2015).

Table 1 GDP Corporate Sustainability

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Agriculture	31,086	36,526	45,116	50,554	54,923.5	25,290	40,554	23.5	4,93	1,08
Crops	3,254	3,646	3,835	4,186	4,342	1,980	186	342	342	254
Cattles	5,572	6,053	6,524	7,100	7528	1826	7,100	728	528	572
Fishing	1,985	2,539	2,841	2800	2808	4,354	800	208	80	985
Forestry	2,892	3,455	3,542	4055	4239	2048	1055	4239	423	892
Industry	53,767	57,155	60,709	78,015	94,770.3	43,104	8,015	4770.3	9770.3	3,767
Mining	21,705	17,131	16,831	25,918	37,999	15,933	25,918	379	399	1,705
Manufacturing	17,605	20,506	23,922	26,860	31,441	14,523	6,860	1,441	1,441	7,605
Electricity	1,378	2,979	3,486	4,390	4,178	1327	390	,178	178	378
Water	896	1183	1305	1415	1470	680	415	170	470	96
Construction	12183	15,357	15,165	19,433	19,683	10,641	9,433	1,683	683	2183

(Source: <http://www.statsghana.gov.gh/>)

We show the GDP contributions from Ghana's agriculture, crops, cattle, fishing, forestry, industry, mining, manufacturing, electricity, water, and construction sectors from 2014 to 2023. As shown in Table 1 below, this extensive research examines patterns and changes throughout time. Agriculture contributed consistently to GDP, rising from 31,086 in 2014 to 54,923.5 in 2018. Crops and cattle also grew steadily.

After falling to 25,290 in 2019, the sector fluctuated in consecutive years. By 2023, the contribution had dropped to 1,080, indicating a significant decrease. Mining and manufacturing boosted the industry's GDP contribution from 53,767 in 2014 to 94,770.3 in 2018. Industry, like agriculture, dropped to 43,104 in 2019 and fluctuated in subsequent years. The value declined to \$3,767 by 2023. Mining fluctuated but climbed from 21,705 in 2014 to 37,999 in 2018. The subsector's contribution dropped substantially to 15,933 in 2019 and varied to 1,705 in 2023. Industrial activity

boosted manufacturing from 17,605 in 2014 to 31,441 in 2018. Following 2018, the number dropped to 14,523 in 2019 and then stabilized at 1,441 in 2023. The electricity and water sectors grew from 1,378 in 2014 to 4,390 in 2017, then dropped to 4,178 in 2018 and 378 by 2023. It increased from 896 in 2014 to 1,470 in 2018, then dropped to 680 in 2019 and 96 in 2023.

Construction climbed from 12,183 in 2014 to 19,683 in 2018, indicating considerable growth. After 2018, the sector fell to 10,641 in 2019 and 2,183 in 2023. After 2018, GDP contributions from agriculture, industry, and their subcomponents plummeted. Mining and manufacturing showed substantial volatility, suggesting external economic causes or internal industry concerns. The agricultural sector's collapse beyond 2018 may imply sustainability issues or major economic developments.

After early expansion, the construction sector's rapid downturn suggests post-2018 infrastructure investment or project completions may decrease. Both sectors experienced significant declines after 2018, indicating difficulties with resource management or utility investment. Most industries experienced a decline after 2018, following a period of strong growth up to that year. This reduction suggests economic disruptions or structural issues in certain sectors. We may need to take strategic actions to address significant sector volatility and losses for sustainable growth.

GDP Corporate Sustainability refers to the integration of sustainable practices within the corporate sector and how these practices contribute to a country's Gross Domestic Product (GDP). It measures how businesses across various sectors contribute to economic growth while simultaneously addressing environmental and social responsibilities, as shown in Table 1 above. This concept ensures that corporate activities do not merely focus on short-term profits but also consider long-term sustainability, balancing economic development with preserving resources for future generations.

4.1.1. Theory of Stakeholder and Legitimacy

After Edward Freeman's 1984 book *Strategic Planning: A Business Governance Perspective*, stewardship theory gained popularity in business and technology studies. Business operations are suggested and possible in the theory. Value creation, trade, and corporate efficiency are involved. Stakeholder management holds firms morally accountable for considering and balancing all parties' interests. Successful companies safeguard owners, borrowers, workers, suppliers, customers, communities, and the public. The conceptual framework has become a knowledge base for organizations to protect stakeholder relationships via corporate social performance. Companies use environmental accounting to involve stakeholders and reduce data asymmetries. Research shows that companies that address stakeholder requirements perform better (Pobbi et al., 2020). Legitimacy is needed to understand how companies create and execute sustainability reports. "A wide perspective or presupposition that behaviors of an organization are acceptable, proper, or suitable given certain socially created systems of norms, values, beliefs, and criteria" describes it. The notion states that a company's interactions with society are a means of justification to ensure that its activities comply with local societal norms and values. Legitimacy theory assumes a social contract between the community and the company (Badu et al., 2012).

4.2. Enterprises in Large Manufacturing

Between 2014 and 2023, the proportion of Ghana's Gross Domestic Product attributed to the production sector declined. The graph shown in Figure 1 illustrates a significant increase from 6% in 2012 to 12% in 2014, providing evidence of this substantial gain. However, the decline to 11% from 2017 to 2023 is concerning and necessitates a resolution. As a result, it is not surprising that Ghana, which has an overall administration score of 108, is among the three lowest ranked out of the 33 research projects being evaluated. The graphical depiction may be seen in Figure 1

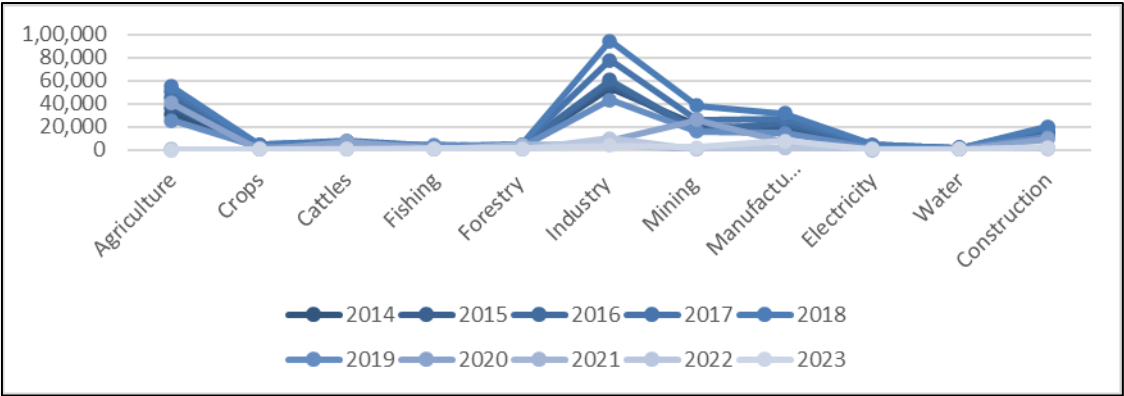


Figure 1 Manufacturing GDP

Management education is crucial in growing countries, especially in industrial enterprises, since differences in management approaches directly impact company performance discrepancies (Alam et al, 2024). One effective approach to improve corporate operations is to provide consulting services specifically tailored for enterprises within the construction industry. Investing in training courses may enhance efficiency for large industrial organizations, as shown in figure 2.

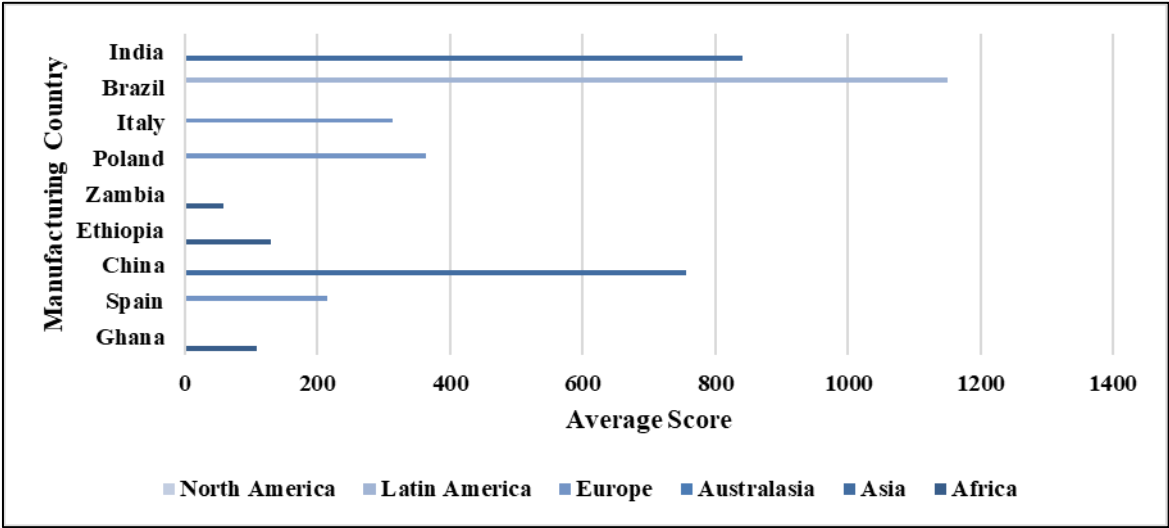


Figure 2 Scores

The yearly rate of increase of GDP is determined by the price of goods and services in the local currency, which remains constant. The foundation for aggregates is a fixed amount of 10 dollars. Gross domestic product (GDP) is determined by summing up the net value produced by all resident producers in the market, including any relevant taxes on goods, and subtracting any unrecorded subsidies. It is derived using a calculation that does not include the decline and depletion of natural resources or the decrease in the value of manufactured assets.

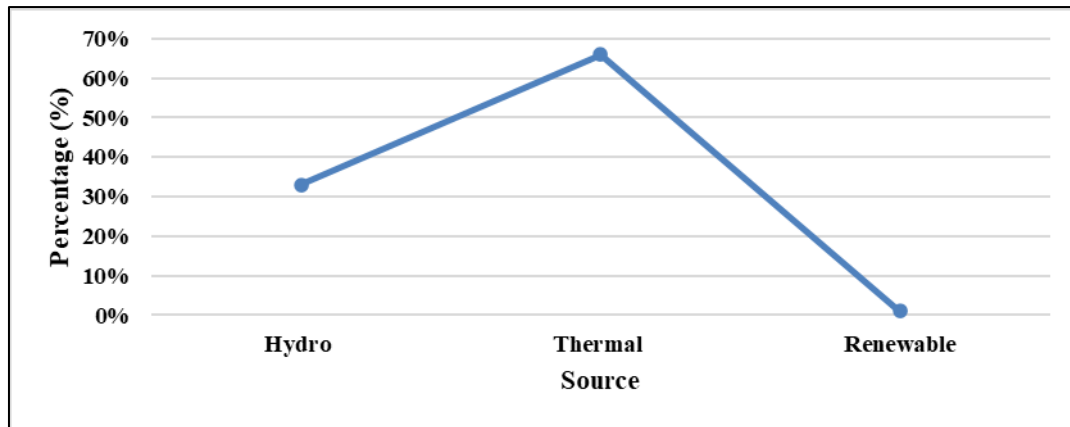


Figure 3 Power Capacity

Ghana relies on hydropower (38.9%) and thermodynamic efficiency (59.9%), which utilize fossil fuels such as oil and gas to generate energy (Energy Commission, 2018). Ghana's capacity is 4398.5 MW, while its dependable capacity is 3643 MW, representing a 19% generating unit increase over 10 years. Figure 3 shows Ghana's hydropower, oil, petroleum, and modern renewable energy resources, while Table 2 shows its electricity production resources, including installed and reliable capacity and fuel usage (Lee & Farzipoor Saen, 2012). Figure 3 compares the state-owned Volta River Authority (VRA) to independent power providers (IPPs), who generate 98% thermally. Figure 4 shows a strong correlation between total energy consumption and the increase in capacity factor and electricity generation from 2014 to 2023. The energy generated increased from 8958 GWh in 2014 to 14,069 GWh in 2017, whereas the amount of final power absorbed increased from 7452 GWh to 12,091 GWh.

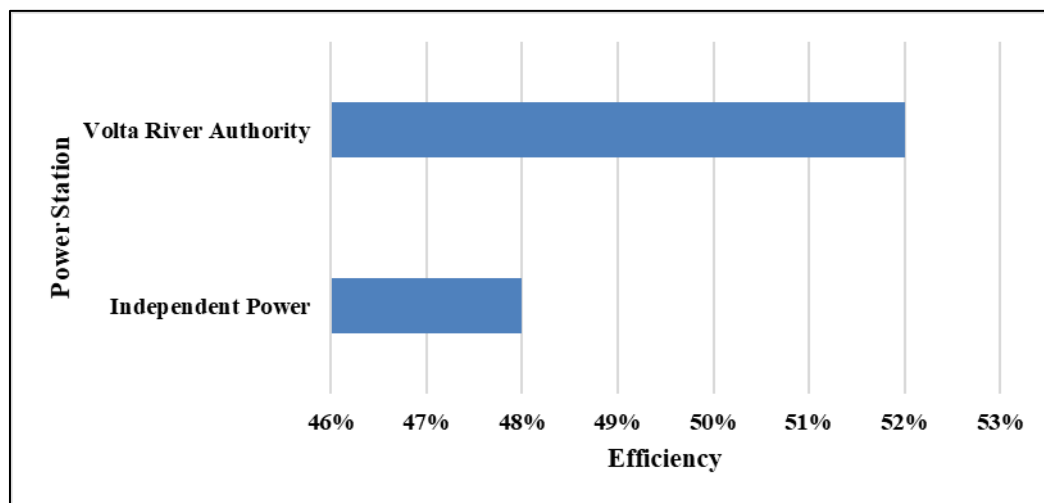


Figure 4 Capacity

The difference between producing capacity and reliable potential for VRA (Ghana's main power-generating corporation) and independent power facilities adds to a 78% dependability rate (Energy Commission, 2018). The higher plant efficiency of 78% is satisfactory compared to regulatory standards of 70–90%. This rises with 811 MW of new capacity. The median dependability of hydroelectric facilities is 81%, compared to 85% for fossil fuel-based electricity plants. The annual drought and environmental deterioration may also lower hydro dependability (Tomšič et al., 2015). Due to rising crude oil prices, gas shortages, and currency devaluation, certain thermal facilities cannot run at full capacity. Therefore, Ghana's power production portfolio should be diversified to reduce its dependence on traditional facilities. The RE business requires extensive study to adapt to the Ghanaian environment and needs rapid attention. A vigorous national debate is underway regarding whether electrical energy or sources should be introduced to solve sustainability issues.

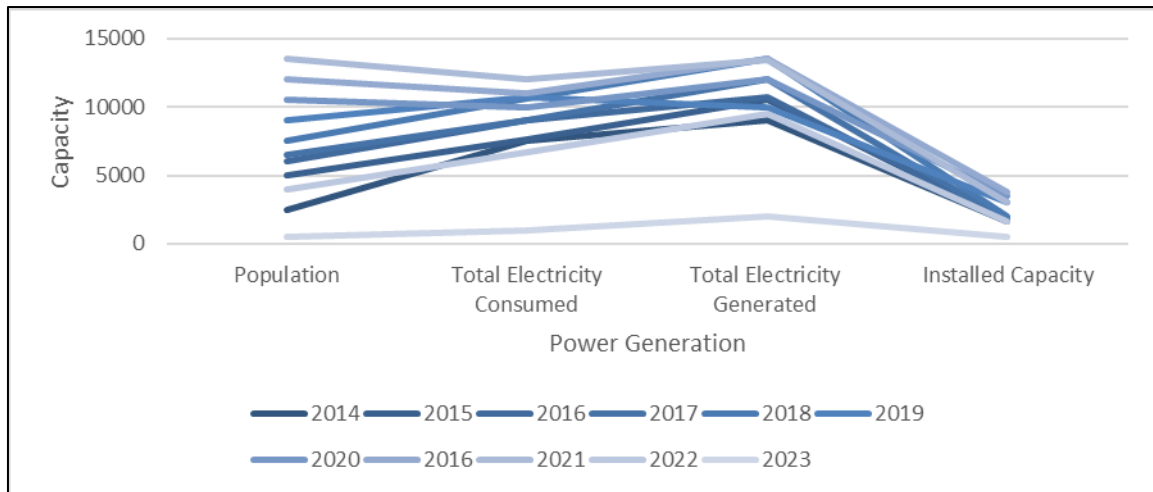


Figure 5 Electricity Generation

The above criteria in Figure 5 indicate innovation by adopting a new approach. Green energy is new in developing countries. Thus, green buildings may be novel. Looking at green technology as a construction invention led to "green innovation." "Green innovations" are "products, processes, systems, substances, and procedures that either cut facility energy consumption or reduce the ecological effect of buildings." The description claims that GBTs, green technology rating systems, and green standards are popular green advances in building projects; however, they overlook human health. In the research study, participants rated each of the 28 suggested green technologies from 1 to 5 (1 being insignificant, 2 less essential, 3 impartial, 4 significant, and 5 extremely essential) to achieve responsible economic activities. Before analyzing the data, the Shapiro-Wilk and Cronbach's alpha coefficient tests determined its normality and reliability. The 28 GBTs' Cronbach's alpha was 0.910. This is much higher than the cutoff value of 0.70, suggesting that the five-point scale evaluation and data are credible for further investigations.

4.3. Cost Benefit Analysis

Cost-benefit analysis (CBA) is a process for weighing the pros and cons of different solutions. It selects solutions that optimize spending while meeting transaction, engagement, and operational customer needs (Duah et al., 2025a). A CBA may evaluate current and potential actions and compute a decision's value to cost. It is often used to evaluate advertising agreements, project investments, and commercial or policy decisions (particularly public policy). The Securities and Exchange Commission (SEC) must conduct a cost-benefit analysis before passing or defragmenting legislation. Therefore, Ghana's power production portfolio should be diversified to reduce its dependence on traditional facilities. The RE business requires extensive study to adapt to the Ghanaian environment and needs rapid attention. A vigorous national debate is underway regarding whether electrical energy or sources should be introduced to solve sustainability issues. Additional expenditures are paid to make a project greener than a regular construction. Thus, meeting green building regulations increases prices. Green buildings incur extra costs from material, technology, administration, and other variables throughout their reproductive life (Shah et al., 2016). The Net Present Value (NPV) and Benefit-Cost Ratio (BCR) were used to evaluate Ghana's Forestry Focused (FF) and Rainforest Alliance and Sustainable Agriculture Network (RA-SAN) approved cocoa's economic advantages. Cocoa plant age impacts pros and cons. The early stages of cocoa production include high foundation costs and non-linear annual benefits throughout the life of the plants. Benefits included cassava, plantain, and cocoyam revenue and timber. Over time, perennial commodities such as cocoa generate costs and benefits. Due to the temporal value of money, future costs and benefits were adjusted to match present values. Compound and discount come to mind. Discounting may "reduce" future earnings and cost to "now worth." An ex-ante evaluation includes projections of productivity per-ha costs and benefits during the farm's estimated 20-year lifespan ($t=20$ years). Using the correct rate of return and per-ha net present value, expenditures and benefits were evaluated in equation (9):

$$NPV = \sum_{e=0}^{\infty} \frac{B_x - C_x}{(1+e)^x} \quad (9)$$

Where

NPV: Net Present Value.

Bx : Benefits in year x

Cx : Costs in year x .

e : Discount rate.

x : Year or period.

Using time value of money calculations, CBA aims to balance costs and benefits across time. Using a discount rate (r), future expenses (C) and benefits (B) are often discounted into present value.

4.3.1. Analysis of Program Implementation Cost

The study findings demonstrate that, except for water, all adaptation techniques in both locations had comparatively modest installation costs, as mentioned. Nsawam's irrigation installation costs (\$4,620) are over twice as much as Keta's (\$2,010). Along with irrigation, strip cropping, and mixed cropping had the highest investment cost in Keta (\$470 and \$126) and Nsawam (\$613 and \$122), respectively). Keta's management costs were highest for irrigation and intermediate for mixed-cropping and intercropping. Nsawam had low costs for crop rotation, mixed cropping, and irrigation but intermediate costs for intercropping and fertilizing. Mixing, fertilizing, and crop rotation cost Nsawam the most, whereas intercropping and irrigation cost the middle of the road (Figure 6).

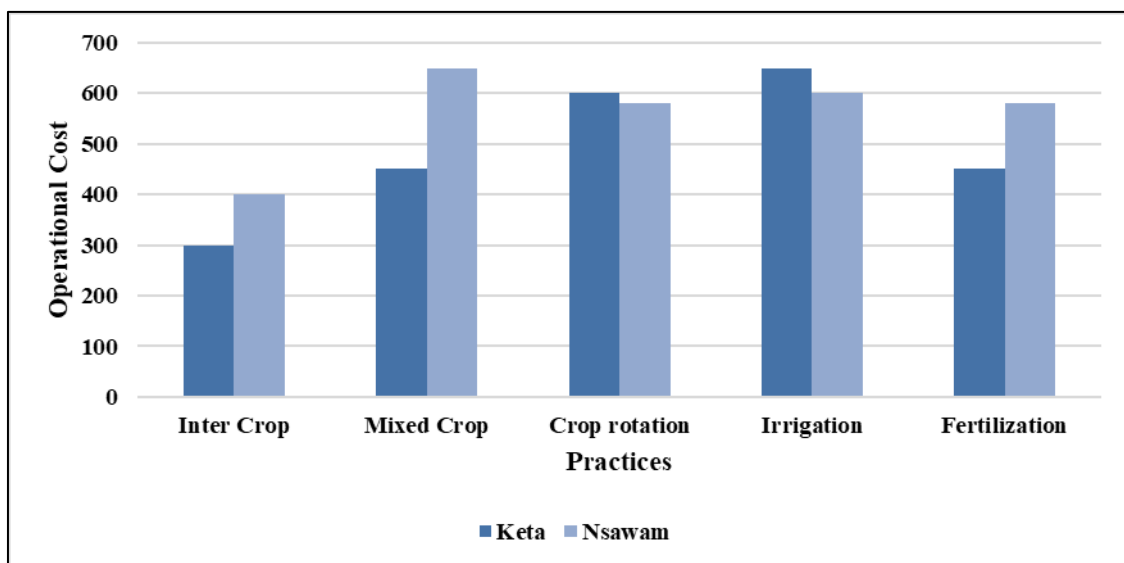


Figure 6 Implementation Cost of irrigation, intercropping, and fertilizing

Consulting fees per plant are the main cost of this process; orientation programs cost \$250,000. Consulting services cost GHS 1,594,262 per firm in 2018, assuming a rate of exchange of 1.4 (GHS per USD) and inflation of 4.56 due to GDP currency depreciation. The idea requires an additional GH 19,131 investment. In 2018, this intervention would cost each plant GHS 1,613,393. The assumption is that Ghanaian companies would pay the same for Indian corporate analysis consulting. The company's primary purpose is to maximize profit, even if management advice services may improve productivity, firm growth, client base, and employment. Thus, delivering training programs and consulting services generates money for the organization. The revenue increase is expected at \$325,000. The investment profit in 2018 is calculated at GH 2,072,541.00 after a 4.56 percent GDP deflator inflation adjustment and a currency value of 1.4 GH per USD in 2009. This advantage may last 6 years if the first trial is followed. Benefit income has a net present value of GHS 9,581,108 at an 8% discount. This method has BCRs of 6.5, 6, and 5 for 5%, 8%, and 14% discount rates. Private enterprises may have found this move costly. Price may be lowered to match the Ghanaian company's budget. Private significant corporations should take this step.

Implications for Policymakers and Businesses in Ghana

The findings of this study carry significant implications for policymakers and businesses in Ghana. The varying costs associated with implementing climate adaptation techniques highlight the need for tailored financial support and incentives to encourage the adoption of these methods across different regions. For instance, the higher installation

costs for irrigation in Nsawam than in Keta suggest that location-specific financial assistance or subsidies might be necessary to promote equitable access to these essential technologies. Moreover, the study's results underscore the importance of developing cost-effective strategies for adaptation, particularly in regions where high investment costs could deter businesses from adopting sustainable practices.

Policymakers should consider developing frameworks that incentivize private enterprises to invest in green technologies, ensuring that cost barriers do not hinder the transition to sustainable practices. As demonstrated by the net present value and benefit-cost ratios (BCRs), the potential economic and environmental benefits suggest that long-term gains can be substantial if initial financial obstacles are addressed. Additionally, businesses should be encouraged to incorporate environmental sustainability into their strategic planning, as the profitability and efficiency gains highlighted by the study indicate a positive return on investment in the long run.

4.4. Challenges and Limitations:

Several challenges and limitations were encountered during the study, which may have influenced the results and interpretations. One major challenge was the variability in cost data across different regions and enterprises. The disparity in costs, such as the significantly higher irrigation installation costs in Nsawam compared to Keta, reflects the complexities of conducting cost analyses in diverse geographical and economic settings. This variability may be attributed to differences in local infrastructure, labour costs, and access to resources, which were not fully controllable within the scope of this study.

Another limitation was the assumption that Ghanaian companies would bear similar costs for consulting services as Indian firms. This assumption may not accurately reflect the actual costs in the Ghanaian context, potentially leading to an overestimation or underestimation of the financial impact. Additionally, the study focused primarily on the financial aspects of climate adaptation techniques, with less emphasis on social and environmental outcomes. Future studies should aim to integrate these dimensions more comprehensively to provide a holistic assessment of the benefits and challenges of green technology adoption.

4.5. Suggestions for Future Research:

Future research should explore several key areas to build on this study's findings. First, more detailed, region-specific analyses that consider the local economic, social, and environmental conditions affecting the implementation of climate adaptation strategies are needed. This could involve case studies of individual enterprises or communities to better understand their specific challenges and opportunities.

Second, future research should aim to refine the cost-benefit analysis models by incorporating more variables related to social and environmental impacts. This would provide a more comprehensive understanding of the actual value of green technologies and sustainable practices beyond just financial metrics. Additionally, exploring the long-term impacts of these adaptation techniques, particularly in terms of resilience and sustainability, would be valuable in assessing their effectiveness over time.

Lastly, further studies could investigate the role of public-private partnerships in facilitating the adoption of green technologies. Understanding how collaboration between the government and private sector can enhance the feasibility and attractiveness of sustainable practices could provide actionable insights for policymakers and business leaders alike.

List of abbreviations

- CSR: Corporate Social Responsibility
- NPV: Net Present Value
- BCR: Benefit-Cost Ratio
- RA-SAN: Rainforest Alliance and Sustainable Agriculture Network
- IDH: The Sustainable Trade Initiative (Initiatief Duurzame Handel)
- MIS: Management Information System
- ROE: Return on Equity
- SEC: Securities and Exchange Commission
- FF: Forestry Focused
- CBA: Cost-Benefit Analysis

5. Conclusion

This study evaluated the efficacy of incorporating a thorough cost-benefit analysis in the decision-making process for implementing five climate adaptation strategies in two agricultural villages in Ghana. The analysis encompassed income and potential risks within both private and governmental sectors. The results demonstrated that all five climate adaptation approaches yielded positive outcomes and financial gains. Additionally, adaptive techniques were shown to promote favourable social and environmental benefits. While intercropping, irrigation, and mixed cropping require substantial financial investments, mixed cropping, and crop rotation emerged as cost-effective strategies. Among the strategies evaluated, irrigation was identified as the costliest to implement.

Furthermore, the study explored the potential for integrating solar PV and biogas by implementing an intelligent power control system, ensuring the optimal use of both energy sources. This hybridization was found to be feasible from both technical and economic perspectives. Key technological options, such as consciousness and feed-in-tariff (commonly known as gross), were identified as potential enhancements to energy efficiency. However, the study cautioned against layering one technology over another, as this approach may not be prudent from a commercial and financial standpoint.

The findings indicate that the hybridization approach, particularly in coastal regions, has significant and far-reaching impacts on communities, contributing to waste management, job creation, and community-based power production. However, sociocultural barriers, such as land availability and the local population's acceptance of green technology, were identified as critical factors influencing the adoption of these technologies in Ghana. Only those issues with a significant connection to the adoption of green technology were considered in the implementation process to ensure the effectiveness of the proposed approach.

The first phase of the infrastructure program involved evaluating the primary factors affecting the acceptability of green technology. This evaluation is essential as consumer motivation is crucial in overcoming obstacles. The dissemination of green technology within the industry and among the public is critical, as influential factors can motivate and guide enterprises in adopting these technologies.

In conclusion, the study underscores the importance of a comprehensive and targeted approach to climate adaptation in agriculture. Future research should focus on developing more robust and effective strategies to ensure sustainable and resilient agricultural practices in Ghana, reinforcing the country's commitment to corporate sustainability and green technology adoption.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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