Review

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Article

Investigating Barriers to Low-carbon Policy Implementation among Mining Companies in Ghana

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Abstract: Efforts for carbon emission reduction have been identified as a major climate change mitigation target in the Paris Agreement. The 26th Conference of Parties to the United Nations Framework Convention on Climate Change highlighted the worldwide effort for cleaner and greener mining, urging the mineral industry to embrace greener operational emissions reduction technologies and strategies. Ghana pledged at the Paris Conference to reduce CO_2 emissions by 15% and increase renewable energy share to 10% of the national energy mix. Ghana's efforts to implement low-carbon policy were, however, hampered by a number of reasons. Ghana is Africa's leading gold producer and the world's seventh largest producer. Mining has contributed significantly to foreign currency acquisition and government revenue. The gold mining sector contributes approximately 95% of Ghana's total mineral revenue. Considering these situations, the fundamental question is how Ghana's mining industry can contribute to CO_2 emission reductions efforts. This paper investigates barriers to low-carbon emission policy implementation among mining companies in Ghana. We adopted a 5-point Likert scale statement questions. The questionnaire survey was conducted among Ghana's four large-scale gold mining companies. As the sample number of available companies is limited, we used a descriptive analysis to assess the responses. The results show that the companies expressed widely different ways to respond to the issues of cost, a government policy for carbon emission reduction, and the acquisition of low-carbon technologies. Those companies that are relatively less prepared for this endeavor emphasized the uncertainties of securing sufficient energy in case of using low-carbon technologies. They also expressed a need for more trained workers to handle low-carbon technologies. We found that a major challenge among companies was the expected cost involved in implementing low-carbon emission policy. There was a communication gap with the relevant government ministry about low-carbon mining options where the government should be able to facilitate the involvement of the low technology providers, such as solar Photovoltaics installation.

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1. Introduction

For decades, international organizations have long anticipated that the mining sector contributes more to realizing low-carbon goals. As early as 1972, recommendation 56 of the Stockholm Action Plan urged nations to create a forum for exchanging information about mining and mineral processing, including the impact of mining on environmental conditions [1]. In 1992, Agenda 21 advocated for more sustainable green mining [1–3]. The 2012 UN Conference on Sustainable Development highlighted the need for strong and effective legal and regulatory frameworks, policies, and practices for the mining industry [3]. The 26th Conference of Parties to the United Nations Framework Convention on Climate Change (COP26-UNFCCC) urged the mining industry to adopt greener operations [4]. The World Economic Forum similarly emphasized the way the mining

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industry can benefit from low-carbon infrastructure development [5]. Major mining companies are now well-aware that their operations must lower carbon emissions [4,6].

The World Gold Council estimates that from 1991 to 2006, the average carbon and other GHG emission intensity from global gold mining was 11,500 kg CO_2-e/kg [7]. Similarly, it investigated carbon and GHG emissions from five large gold producers in 2016 and found that an average emission intensity was 23,300 kg CO_2-e per one kilogram of gold produce, significantly higher than the global average [8]. Mineral extraction activities significantly intensify climate vulnerability [9]. GHG emissions intensity in Australia's mining industry increased by 40% from 14,100 kg CO_2-e/kg in 1991 to 19,740 kg CO_2-e/kg in 2006 [10].

When Ghana ratified the Paris Agreement in September 2016 [11], its carbon and other GHG emissions had been in an increasing trend. According to its fourth Nationally Determined Contribution (NDC) to the UNFCCC, which was submitted in May 2020, the total CO_2 and other GHG emissions in 2016 were estimated to be 42.2 million tons of $MtCO_2e$, a 7.1% increase from 2012 [12]. The NDC targeted at agriculture, forestry, land, energy, waste, industry sectors [12], but, for some reasons, it did not include emissions from the mining and mineral sectors [13].

Ghana pledged at the Paris Conference (2015) to reduce CO_2 emissions by 15% and increase renewable energy share to 10% through the national energy mix. However, its efforts to implement a low-carbon policy were hampered by a number of reasons. Adenle et al. [16] identified lack of finance as a key challenge to achieving low-carbon development strategies (LCDs) in developing countries, particularly in Africa. Benefoh and Ackom [13] similarly highlighted the challenge of finance and ineffective institutional capacity. Other prominent challenges include insufficient financial incentives, firm's policy framework and relationship between the government and corporations affect policy adoption [17].

Here we proposed three hypotheses. (1) Perceptions about cost associated with carbon emission reduction policy implementation of policies vary among Ghana's gold mining companies regarding the costs (cost perception) [16]. These perceptions influence their operations. (2) The effectiveness of the current governmental policy framework for reducing carbon emissions in Ghana influences the willingness of gold mining companies to adopt and implement low-carbon strategies (policy framework impact) [11,13,14]. (3) The readiness of gold mining companies in Ghana to adopt low-carbon technologies is influenced by uncertainties in the energy supply and the availability of expertise in adopting innovative low-emission technologies (technology adoption readiness) [13].

Ghana is Africa's leading gold producer and the world's seventh largest producer [15]. Mining has contributed significantly to its foreign currency acquisition and government revenue. The gold mining sector contributes approximately 95% of Ghana's total mineral revenue. Large-scale gold mining operations accounted for about 11% of Ghana's national GHG emissions [14]. Considering these situations, the fundamental question is how Ghana's mining industry can contribute to CO_2 emission reductions. What is the status of their low-carbon practices? What are their perspectives and prospects of moving toward more sustainable practices of gold production in the future?

This paper, therefore, investigates barriers to low-carbon emission policy implementation among mining companies in Ghana. It focuses on four gold mining companies. Understanding and addressing hinderances to the implementation of carbon emission policies in Ghana's mining sector is crucial for aligning economic development with environmental sustainability and meeting international climate commitments. In the following discussion, we first clarify materials and method. It explains about the study area and our methods of collecting and analyzing data. We then discuss the results pertaining to the company's perceived barriers to adopt low-carbon practices.

2. Materials and Method

2.1. Study Area

For this study, we selected the southern part of Ghana, an area with a rich mineral resource endowment. During the 18th century, Ghana was known as the Gold Coast under the British colonial rule and was home to approximately 12 major large-scale mining companies [14,18]. These mining

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operations were dispersed across various regions within the southern area or so-called the "gold belt." The gold belt is home to almost 90% of the country's total estimated gold deposits [19].

Notable mining zones within this area include Upper Denkyira West, Obuasi, Asutifi North, and Tarkwa, all of which have a longstanding history of gold mining activities [20]. Upper Denkyira West District in the Central Region encompasses an area of 579.21 km^2 and houses a population of 91,025 [21]. Obuasi is a town in the Ashanti Region, covering approximately 162.4 km^2. This area is widely known for its prosperous gold mining activities. The town has a population of 104,297. Asutifi North District in the Ahafo Region encompasses 936 km^2 and is inhabited by 73,556 people [21]. In the Ahafo Region the Ahafo Gold Mine is operated by the Newmont Mining Corporation [22]. Tarkwa, a town in the Western Region, serves as a center for gold mining. Its mining operations are prominently associated with the Tarkwa Gold Mine, operated by GoldFields Limited. The town has a population of 218,664 in a land area of 97,826 km^2. Tarkwa is one of the largest gold mines in the nation [20].

Mining operations exert a multifaceted influence on local livelihoods and developments. In 2020 alone, Ghana produced about five million ounces of gold [23,24], accounting for about 90% of the total mineral exports, and 49% of the total export value [25]. The government of Ghana receives 10% of the mining revenue in the form of taxes and royalties. The mining companies also create employment opportunities [26]. In 2023, a total of 12,294 people were employed in the mining industry in Ghana [27]. More importantly, mining enterprises have invested substantively in infrastructure developments, such as roads, educational institutions, healthcare facilities, and essential amenities [28]. Mining corporations have undertaken corporate social responsibility initiatives for education and healthcare [29].

Mining companies also have shown commitment to responsible and sustainable practices. For instance, the Tarkwa Goldfields Mine emphasizes environmental stewardship, community development, low-carbon practices in its infrastructure and community projects as well as safety measures [30]. Similarly, AngloGold Ashanti, which oversees the redevelopment of the Obuasi mine, says that it adheres to carbon emission reduction, community engagement, safety, and environmental protection [31]. In Upper Denkyira West, Newmont's Akyem mine announced that it has prioritized environmental stewardship, safety, and community development through rigorous environmental assessments, biodiversity conservation efforts, and safety protocols [23,32]. In Asutifi North District, Perseus Mining declares to maintain industry-standard emission reduction, safety, and environmental practices at the Edikan mine while actively engaging with local communities. These expressed efforts illustrate mining industry's growing interests in sustainable and responsible operations [33].

However, the presence of mining operations has long raised concerns over carbon/environmental footprints. Previous research identified that sizable gold mining operations (e.g., land use, explosives, mobile and stationary equipment fuel consumption, electricity consumption, waste disposal) were responsible for a substantial amount of CO_2 and GHG emissions [14]. Among these factors, electricity usage and fuel consumption in transportation account for 92.46% of the overall GHG emissions. On average, the large-scale gold mining sector in Ghana contributed about 11% to Ghana's total national greenhouse gas emission inventory [14].

2.2. Data Collection and Analysis

To gather information on the low-carbon practices of mining companies in Ghana, we initiated contact with company representatives. With permission, we conducted expert interviews using a semi structured questionnaire format. These interviews were conducted between April 27 and May 20, 2022. For confidentiality purposes, we have denoted these companies as Company A, Company B, Company Y, and Company Z (Figure 1). These four companies are recognized as major international mining enterprises in Ghana with operations spanning various mining zones [23].

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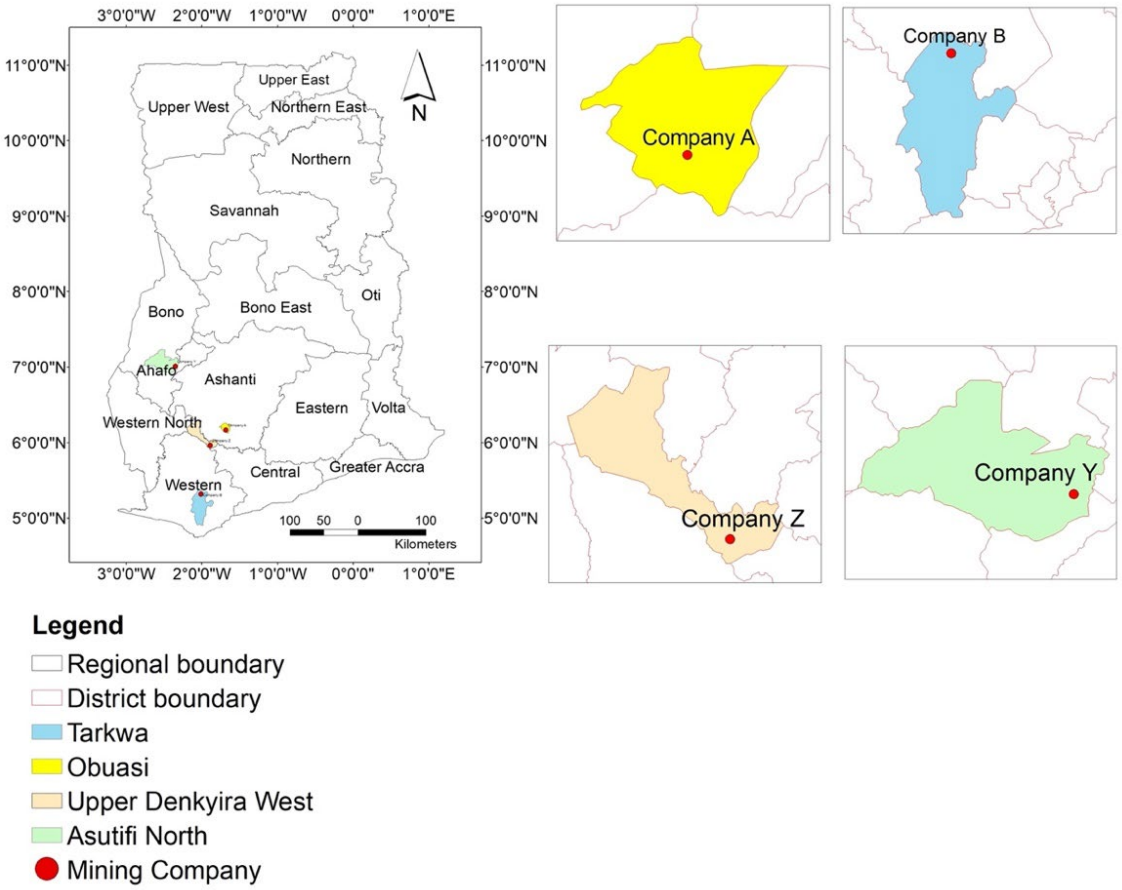

Figure 1. The map illustrates study locations.

In Ghana, Company A operates a gold mine in Obuasi. It is a prominent global gold producer with headquarters in South Africa. Company B also has South African roots and operates a mine at Tarkwa. Company Y is headquartered in Australia with operations at Ahafo. Company Z operates gold mines in the Upper Denkyire West area. Its headquarters is located in the United States [23].

All four companies (Company A, Company B, Company Y, and Company Z) are members of international organizations, including the International Council on Mining and Metals (ICMM), Task Force on Climate-Related Financial Disclosure (TCFD), Extractive Industries Transparency Initiative (EITI), and World Gold Council. All except Company Z are members of the Carbon Disclosure Project (CDP), an international non-profit organization that focuses on environmental reporting and the collection of information related to potential low-carbon practices [34].

The four companies operate gold mining in different scales. Company B was the largest employer among the four companies with a workforce of 4,576 employees. Company A employed approximately 4,210 individuals. Company Z had around 3,343 employees. Company Y employed 2,000 people. In terms of gold production, Company B was the highest producer with an annual output of 526.3koz. Companies Y and Z produced 270koz and 157koz, respectively, while Company A's annual gold production was approximately 127koz [32]. Company A reported an annual estimated revenue of US$4,427 million from gold sales. Company B's annual revenue was about US$927.7 million. Company Y reported an annual revenue of US$467.8 million, and Company Z's annual revenue was US$139.4 million [32]. Table 1 shows these companies' workforce, annual gold production and revenue generated from sales of gold.

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Table 1. Characteristics of Gold Mining Companies.

Company	Workforce	Gold production (Annual) Koz	Revenue (Annual) Million (US$)
Company A	4,210	127	4,427
Company B	4,576	526.3	927.7
Company Y	2,000	270	467.8
Company Z	3,343	157	139.4

According to the Sustainability Report (2021), Companies A and B reported carbon dioxide emission levels of 40 kg/t CO_2e and 33 kg/t CO_2, respectively, for the year 2020. Companies Y and Z primarily focused on scopes 1 (direct emissions) and 2 (indirect emissions) in their carbon emissions intensity assessments without providing specific numerical figures. All four companies rely on grid electricity for their mining activities. However, Company B supplements its energy supply with solar and natural gas [27,35].

Due to the COVID-19 pandemic that prohibited us from conducting in-person survey in Ghana, the survey was carried out by two local enumerators. Based on the information we obtained from published sources, we made a set of questions for the survey. The enumerators strictly adhered to these questions. One enumerator was responsible for Company A, while the other handled companies B, Y, and Z. To ensure clarity, we had detailed phone discussions with the enumerators, explaining the questionnaire contents thoroughly. Responses were received from the environmental departments of the respective companies.

Our questionnaire interviews focused on identifying the companies' challenges in adopting low-carbon technologies. We listed the following eight possible barriers for the respondents to choose: (1) lack of government policy on low-carbon emissions, (2) information availability on low-carbon mining, (3) cost of low-carbon technology, (4) the availability of long-term payment schemes, (5) availability of low-carbon technology, (6) power generation capacity, (7) low-carbon policy decision making and (8) technical expertise. We assessed the degree of their agreement by defining 1 as strongly disagree and 5 as strongly agree on a 5-point Likert scale. To protect respondent anonymity due to the sensitivity of their opinions, we maintained confidentiality.

To understand perceptual variations among the company's responses, we conducted mean analysis to compare the average rating of each mean value on 5-point Likert scale intervals to determine the overall responses. The ranges on 5-point Likert scale intervals and mean values were calculated as follows:

Step 1: To estimate the Likert scale ranges, we first computed the average value by:

1. Subtracting the 5-point Likert scale lowest value from the highest value (5-1=4)
2. Dividing by the 5-point Likert scale number of responses (4/5=0.8)
3. Then added (0.8+1=1.8). Where 1=Lower standard range (scale of 1 to 5) and 0.8 is the average mean value. Since the 5-point Likert scale has a range of 1 to 5, we expressed the first range as (1–1.8), where 1=Lower range and 1.8=Upper range
4. We added 0.8 to obtain the following upper ranges. [(1.8+0.8=2.6), (2.6+0.8=3.4), (3.4+0.8=4.2), (4.2+0.8=5)]
5. The lower ranges are determined as a sequence value of each upper range

[(1.8 → 1.9), (2.6→ 2.7), (3.4 → 3.5), (4.2 → 4.3)].

6. We computed ranges and interpretation was made as "strongly disagree" (scale 1 to 1.8), "disagree" (scale 1.9 to 2.6), "not sure" (scale 2.7 to 3.4), "agree" (scale 3.5 to 4.2), and "strongly agree" (scale 4.3 to 5).

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Step 2: To find the mean values (Table 2), we modified frequency mean distribution formula and developed an equation: $(\sum R)/TNC$. Where ∑R=Sum of responses and TNC=Total number of companies.

Table 2. Calculation of mean values.

$TNC = 4$			
Responses Rate (Table 3)	$(\sum R)$	$(\sum R)/TNC$	**Mean Value**
Statement 1	4+2+3+4=13	13/4	3.25
Statement 2	1+5+2+3=11	11/4	2.75
Statement 3	5+5+4+5=19	19/4	4.75
Statement 4	4+4+5+2=15	15/4	3.75
Statement 5	1+1+2+1=5	5/4	1.25
Statement 6	1+2+1+2=6	6/4	1.50
Statement 7	4+5+2+4=15	15/4	3.75
Statement 8	4+3+4+4=15	15/4	3.75
∑R=Sum of responses and TNC=Total number of companies.			
(Scale 1 to 5): SD=1, D=2, NS=3, A=4, SA=5 (Reference Table 3)			

Table 3. Companies' responses about low-carbon implementation barriers.

Statement	Company A Mines	Company B Mines	Company Y Mines	Company Z Mines	Mean	Interpretation
1. The government does not give us specific policy frameworks to reduce carbon emission	Agree	Disagree	Not sure	Agree	3.25	NS
2. Mining companies do not have sufficient information about low-carbon-emission	Strongly disagree	Strongly agree	Disagree	Not sure	2.75	NS
3. Low-carbon technology is costly	Strongly agree	Strongly agree	Agree	Strongly agree	4.75	SA
4. We need long-term payment plans for acquiring low-carbon technology	Agree	Agree	Strongly agree	disagree	3.75	A
5. Low-carbon technology is not available	Strongly disagree	Strongly disagree	Disagree	Strongly disagree	1.25	SD
6.Low-carbon technologies is not our priority	Strongly disagree	Disagree	Strongly disagree	Disagree	1.50	SD
7. Electricity produced by low-carbon technologies is insufficient for mining operation	Agree	Strongly agree	disagree	Agree	3.75	A

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8. We need more trained workers to handle low-carbon technologies	Agree	Not sure	Agree	Agree	3.75	A

NS-Not sure, D-Disagree, SD-Strongly disagree, A-Agree, SA-Strongly agree.

Mean values were estimated as "3.25", "2.75", "4.75", "3.75", "1.25", "1.50", "3.75", "3.75". Responses with a higher mean value suggest a greater potential barrier, whereas responses with a lower mean value imply a least barrier to implementing low-carbon policies.

3. Results and Discussion

Company's Responses to Barriers to Low-Carbon Policy Implementation

One of the important questions we do not know about low-carbon policy implementation among mining companies in Ghana is the extent to which government agencies have communicated with mining companies about the policy. In other words, to what extent are companies aware of government incentives for low-carbon options (Table 3)? This point has been emphasized in past studies [17,36].

In response to this question, companies A and Z were of opinion that the Ghanaian government did not provide specific low-carbon emission incentives. Company B replied that the government had provided low-carbon policy information. Company Y was not sure. This result means that, overall, mining companies did not seem to have good communication with government agencies about low-carbon policies. In Ghana, the Ministry of Environment, Science, Technology and Innovations (MESTI), and the Environmental Protection Agency (EPA) enforce compliance with environmental laws and regulations at all levels [12]. The primary tax advantages and incentives for private entities engaged in mining activities in Ghana revolve around reduced customs import duties for plant, machinery, equipment, and accessories exclusively imported for mineral operations [37].

In the next question, we asked whether the mining companies had sufficient information about low-carbon technologies and options. This question was based on the study by [38] who suggested that the corporate organizational structure and managerial perspectives significantly influence firm's ability to obtain information. In response to our question, companies A and Y strongly disagreed and disagreed about having sufficient information about low-carbon technologies and options. On the contrary, company B was confident that it had enough information with or without government information. Company Z was not sure.

Next, we asked the companies about the extent to which the cost for adopting solar and wind technologies were to be obstacles. According to GoldFields' 2021 Sustainability Report, Agnew Mines' renewable energy installations were recommended to be handled by independent power producers due to the large capital required to invest in renewable energy (IPPs). The independent power producers are private electricity suppliers who invest in corporate renewal energy production. However, past studies showed that the higher costs associated with adopting solar and wind technologies imposed a burden on private firms [39,40]. This is particularly so when developing countries, not having their own solar/wind producers, depend on imports with additional cost for import duties [41]. In response, all four companies agreed that the cost was one of major inhibiting factors (Table 3).

As mining is an energy-intensive industry, we asked the companies if energy generated by low-carbon technologies would be sufficient for their mining operations. In response, Company B strongly believed that low-carbon technologies would not supply sufficient energy for their operations. Companies A and Z agreed. Company Y disagreed with the statement, showing its capacity to incorporate renewable energies for its operation. This result (Table 3) shows varied responses among companies. Overall, this result suggests that electricity produced by low-carbon technologies is considered to be insufficient for mining operation, but this does not mean that all mining companies are incapable of adopting low-carbon technology.

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Concerning policy decision making within the area of their companies' operations, we questioned about the extent to which the companies agreed that low-carbon technology is not emphasized at the top of the company policy agenda. All the companies disagreed (Table 3), suggesting that these companies placed a high priority on reducing carbon emissions. Among them, two companies (A and B) strongly disagreed, whereas the rest disagreed (company Y and Z). The study of the range by mean interpretation reveals that all four companies strongly disagreed (Table 3).

In terms of technical competence, we asked about the extent to which the companies were capable of managing low-carbon technologies by available workers. Companies A and Z agreed that additional technical knowledge is required to handle updated low-carbon technologies. Company Y was not sure (Table 1). We found that all elements of innovation, including adoption, operation, and maintenance, require technical skills. The skill level and capacity differed widely among companies.

4. Conclusion

This paper has discussed barriers to implementing low-carbon practices at Ghana's four main gold mining companies. Reflecting on what we discussed in the introduction, our findings should be once again placed within a context of global movement toward climate smart mining initiatives. Whereas the international community emphasized the importance of incorporating low-carbon options into the mining sector, past studies have not yet clarified how individual companies are ready for this undertaking. In addition, it has not been found that how mining companies are operating in developing countries, in which strong legal/regulatory frameworks are not put in place in connection to climate smart actions. These questions are essential to make international low-carbon mining propositions more feasible.

Our paper examined four gold mining companies that are recognized as large-scale international mining enterprises that are operating in Ghana, primarily producing gold as key production activities. We discussed that these companies are the members of the International Council on Mining and Metals, Task Force on Climate-Related Financial Disclosure, Extractive Industries Transparency Initiative, and World Gold Council. This means that these companies had substantial knowledge about low-carbon mining options. Even though the companies recognized the need to reduce their carbon footprint, the results of our survey showed that overall cost concerns were the major barrier for all companies.

Another salient finding in this research was that the level of knowledge and capacity in dealing with their low-carbon operations in Ghana differed widely among companies. This can be translated into the question of the extent to which each company was committed to low-carbon efforts. Companies A and Y, for example, appeared to be more knowledgeable and committed to low-carbon operations than the others. In another words, challenges large-scale gold mining companies face differ partly because there is a large disconnect between responsible government agencies and company's practices. In terms of acquiring sufficient technical expertise/resources and installing renewable energy sources (e.g., solar, wind), companies have decision making power without much regulatory constraints.

We found that one of the major challenges among companies was the expected cost of material intensive low-carbon technology, which, to some extent, depends on the extraction of mineral resources. Past research highlighted that independent power producers may develop large-scale solar and wind projects, sell electricity to mining companies, and significantly contribute to energy efficiency improvements that, in turn, reduce mining carbon emissions. This was not done yet in Ghana partly because the Ghanaian government has not invested in its own low-carbon technology developments. There is also a lack of public-private partnership options for the mining industry in Ghana.

Our studies revealed that technical knowledge is required to handle innovative low-carbon technology within the mining companies. Previous studies observed that managing cutting-edge technologies required professional expertise as well as company's strong commitment to investing in these technologies. If strongly committed, mining companies may create their own technologies in Ghana. Also, with enough investment in education, Ghana's private sector may eventually provide

outsourcing options for these mining companies in connection to adopting, operating, and maintaining technologies. The Ministry of Education in charge of designing the educational curriculum in Ghana may incorporate low-carbon technology requirements.

Finally, we acknowledge that further research is needed to understand the cost-effectiveness of adopting low-carbon technology among mining companies. In particular, we need to know the extent to which tighter low-carbon or climate smart regulations in Ghana and other resource rich developing countries lead to low-cost technology and management innovations. This type of study may provide more specific guidelines for low-carbon mining operations in the future. Another fundamental question in the context of Ghana's mining sector and possibly beyond is the question of control over mineral resources. Given the dominant presence of foreign mining corporations, it is important to examine how Ghana can regain more control over its natural resources for its sustainable and climate smart future.

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Data Availability Statement:

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