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Environmental Safety and Sustainability in Ghana's Gold Mining Sector

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***Abstract*—** *The practice of gold mining is seeing remarkable growth and has emerged as a significant source of income for a large number of inhabitants in the geographical regions where it is carried out. However, despite the recognition of this potential, the process of extracting gold presents several challenges for everyone involved, with the safety and well-being of miners being particularly precarious. Our study aims to examine the occupational safety and health (OSH) practices utilised in Ghana's precious metals mines to provide valuable information to important stakeholders and authorities. Overall, the findings offer a comprehensive analysis of the welfare issues faced by individuals in Ghanaian gold mining communities. The foundation of our study is rooted in both theoretical and empirical investigations. We utilised a statistical methodology to sample all 110 individuals that participated in our survey. Through the implementation of a case study, we apply regression analysis and descriptive statistics to investigate the correlations among the variables and ascertain the strategies utilised to achieve a harmonious equilibrium between security, financial prosperity, and environmental sustainability. Our investigation uncovered a lack of Occupational Safety and Health (OSH) supervision of various systems. The main causes of crashes were identified as mechanical, physical, chemical, biological, auditory, ergonomic, and mental risk factors. This results in injuries, deaths, and instances of employees being absent from work. Furthermore, our study lacked references to the absence of occupational safety and health (OSH) regulations and protocols aimed at improving the extraction of precious metals. Our studies also examine the governance of the precious metals extraction project in Ghana, including its impact on the landscape, economic prosperity, and ecological stewardship. The findings indicate that there are instances of non-compliance with occupational safety and health regulations in the gold mining sector within the research region. Hence, the inquiry proposes achieving a harmonious equilibrium among safeguarding, financial prosperity, and sustainable growth. Attaining workplace health and safety requirements, boosting Ghana's economic output, and ensuring the longevity of the environment can be achieved by increasing the use of protective clothing and regularly incorporating aerial photography into governmental evaluations of gold extraction operations.*

I. INTRODUCTION

1.1 Background

This section reviews studies on Ghana's mining industry's social and environmental sustainability strategies. Since the mining industry's social sustainability methods are usually part of CSR (Essah & Andrews, 2016), this section will also analyse them in Ghana. Social and environmental sustainability in developing nations defines a company's CSR operations, according to the literature. Thus, this section examines Ghana's large-scale mining sector's sustainability and CSR. Sustainability in South American mining has been studied (Loayza & Rigolini, 2016; Viveros, 2016). Thus, this part analyses sustainable implementation qualities using the latest research. As to Agyemang, Agyemang, Ansong, and Ansong (2017), CSR is new to the national institutional landscape but has gained popularity, especially in business. Businesses in banking, mining, and telecoms have adopted the idea by following essential statutory requirements (Agyemang et al., 2017). Oppong (2016a) says CSR initiatives often improve children, the environment, health, social entrepreneurship, and sports. This calls into question your sustainability understanding. Some of Ghana's environmental and social sustainability programmes exceed their CSR or sustainability implementation level, as shown in Table 2.4. Ghana may employ a lot of hydropower, which minimises greenhouse gas emissions. Large enterprises voluntarily disclose their energy use to global reporting organisations like the Global Reporting Initiative and ISO 14001. Table 2.4 shows that sustainability problems must be addressed during the mine's operating period upon closing. To meet Ghana's Minerals and Mining Act, 2006 (Act 703)'s minimum standards, land restoration, reforestation, and chemical spill avoidance are social sustainability initiatives (Oppong, 2016a). Social sustainability, a developing term, varies from CSR owing to its broader conceptual similarities. Ghana may overemphasise CSR implementation as self-regulatory, which may explain certain sustainability difficulties. Ghana's social sustainability efforts, according to Andrews (2016), are fragmented CSR programmes that contradict sustainable practices. CSR programmes prioritise physical initiatives above social sustainability (tangible and intangible) after mine closure owing to the operational implications of mining. According to Andrews (2016), voluntary CSR programmes threaten social sustainability in Ghana's extractive economy. Social sustainability may involve volunteer initiatives, mining-induced displacement legislation, development partnerships, and regulatory compliance processes. Multinational companies' CSR agenda limits mining stakeholders' capacity to challenge large-scale mining operations (Ross, 2017). In mining-related social problems, the state and major mining firms often oppose impacted communities and civil society organisations (Tetreault, 2020). The institutional framework of developing nations negatively impacts managerial cognition, or how managers make sense of their environment, which threatens mining regions' long-term viability. Ghana's sustainability efforts prioritise land restoration, impact reduction, and community growth. The usual CSR method for neighbourhood protection is also criticized in this study. The poor institutional structure that limits compliance monitoring and regulatory enforcement is the main cause of Ghana's sustainability implementation problems (Andrews, 2016). Thus, multinational mining companies' social sustainability strategies are more significant. The following observations provide a framework for studying social sustainability theoretically and empirically.

1.2 Historical Mining Growth In Ghana

The development of the country's economy has been considerably aided by Ghana's mining sector. The pre-colonial age, when this region had a long and rich history, saw a substantial amount of wealth coming from gold mining. Bauxite, manganese, diamonds, and most recently, oil and gas, were among the various minerals that were added to the industry over time. The most renowned of Ghana's several irreplaceable mineral resources is gold. The nation, which is the largest producer of gold in Africa, is among the top 10 producers of the metal globally. The growth of Ghana's economy, gains in foreign exchange, and export income have all been significantly influenced by the gold mining industry.

The mining sector in Ghana is governed by a legislative system that defines rules for mining operations. Mining operations are governed under the Minerals and Mining Act, 2006 (Act 703) and its further revisions. The Ministry of Lands and Natural Resources, which is also in charge of regulating the business, is responsible for developing the regulations that will ensure its long-term viability. The primary regulatory authority, the Minerals Commission, issues licenses and keeps an eye on compliance with mining laws.

The Ghanaian government has recently paid increasing attention to the need for moral and environmentally friendly mining practices. Initiatives have been taken within the mining sector to enhance CSR, community development, and environmental protection. This includes efforts to guarantee the equitable distribution of mining profits, decrease the negative environmental effects of mining operations, and promote favorable social results for individuals residing nearby. Reading the overview will

enable readers to get a context-specific understanding of the historical evolution, legal system, and economic significance of the mining industry in Ghana. The review's subsequent sections can analyze how mining has affected various facets of the Ghanaian economy using this information. Gold Since gold has been mined in Ghana for a very long time, it continues to be a significant location for mineral wealth. After South Africa, Ghana is the continent's second-largest producer of gold. The country's exports and foreign exchange earnings are greatly boosted by the export of gold. Through taxes, royalties, and earnings, it offers a sizable source of employment to the government and financial assistance.

1.3 Motivation and Contribution to the Study

The motivation and contribution to the study are essential aspects of any research, and in this case, they play a crucial role in understanding why this study on safety, financial performance, and environmental sustainability in Ghana's gold mining sector is important. the motivation for this study stems from the need to address critical issues in Ghana's gold mining sector, and its contributions include generating data and insights that inform decision-making, promote sustainability, and enhance the overall understanding of the industry's impact.

II. LITERATURE REVIEW

2.1 THE RELEVANT LITERATURE

Appreciating the hyperlink between social obligation and trustee duties could offer a means of encouraging the minerals sector to behave appropriately. To carry out such procedures, the mining sector has to acknowledge that social accountability is not incompatible with financial prosperity (Carroll, 2015). This empirical study aimed to comprehend the links between corporate fiduciary duty owed to its stakeholders, social responsibility, environmental policies, and societal concerns among Ghanaian gold mining enterprises. We talk about the gap in the relevant literature in Chapter 2 of this study. Some of the topics that will be covered include Ghana's corporate social responsibility, the mining sector there, and its relationship to trusteeship. We concluded this section by highlighting the importance of the current inquiry and summarizing the findings from the chapter.

In the opinion of Hilson (2017), Guyana is a success case' within a handful of nations that utilized an alternate route to the development of the minerals industry. The mineral extraction sector is dominated by local modest mining firms, which has significantly aided its financial growth, but Hilson questions how the sector could have been allowed to avoid the negative effects of the resource curse. As noted by Hilson (2017), a specific feature of gold-rich nations such as Papua New Guinea, Ghana, the Philippines, and Peru, in addition to their respective positions in extraction industries, is that gold is the main objective of mineral extraction, and the business primarily focuses on exporting its goods, which does not contribute to the social and economic advancement of these nations. In addition, he indicates that the constant international need for gold for ornamentation and investment in commodities has spurred the gold mining industry worldwide. Additionally, international donors have encouraged nations who are developing to boost their extraction sector's vulnerability to global expenditure and to enlarge the minerals sector to encourage investment and grow the global economy as a whole. Over several years, multinational mining enterprises have received exemptions from taxes and other inducements from the countries where they operate, the minerals industry has developed, and yet the financial gains have declined.

2.2 The Mining Sector in Ghana

This is the result of these operations. The mining industry in Ghana employed 12,148 people and generated G$1.24 billion ($35.4 billion) for the government in 2014, according to the Ghana Chamber of Mines (2015). Luiz and Ruplal (2013) review research results, personal license plate calculations with senior executives, and elements affecting the global mining industry to establish the characteristics of African mining operations.

2.3 Prior Studies and Research on how Mining Affects Ghana's Economy

Many studies explore Ghana's extraction-related finances. These studies evaluated how mining affects GDP, employment, fiscal responsibility, sustainable development, and social impacts. Many Ghanaian studies have addressed extraction and income growth. Using statistical methods, Amankwah and Anim-Sackey (2018) studied coal's GDP impact in Ghana. Their businesses discovered that drilling helped the economy, proving the industry's importance. The immediate and long-term consequences of quarrying on employment have been explored. Mining communities were less poor and lived better. More studies have studied how extraction impacts fiscal revenues. Ghana Revenue Authority data was used by Bawumia et al. (2015) to examine extractive industry revenues. They discovered that extraction dramatically increased constitutional tariffs, compensation, and bonuses, which supported roads and vital services. The environmental sustainability of Ghanaian extraction has been researched. Gyamfi et al. (2019) examined extractive industries' local environmental implications. Forest loss, filthy water, and soil erosion were connected to mineral

mining. The report underlined the need for strict environmental laws and eco-friendly mining technologies to mitigate these effects. Also addressed were extraction's consequences on community growth and social tensions. Many studies explore Ghana's extraction-related finances. These studies evaluated how mining affects GDP, employment, fiscal responsibility, sustainable development, and social impacts. Many Ghanaian studies have addressed extraction and income growth. Using statistical methods, Amankwah and Anim-Sackey (2018) studied coal's GDP impact in Ghana. Mining's impact on Ghana's economy is well studied. The study examined how mining sector components affected social results, employment growth, tax income, and environmental sustainability. Several empirical studies have examined Ghana's mining and economic growth. Amankwah and Anim-Sackey (2018) used econometrics to study mining's impact on Ghana's GDP. Mining drives economic growth, proving its importance. Studies have examined how mining will affect employment now and later. They discovered that mining jobs supported nearby businesses. Mining locations offer better living conditions and less poverty. Research shows mining affects tax revenues. Using Ghana Revenue Authority statistics, Bawumia et al. (2015) examined Ghana's mining industry's fiscal contributions. Their findings showed that mining increased tax revenues, royalties, and profits, funding infrastructure and public services. A Ghanaian mining study emphasises sustainability. The ecology of mining areas was explored by Gyamfi et al. (2019). Deforestation, water pollution, and soil deterioration resulted from mining. The research recommended strict environmental restrictions and ethical mining to mitigate these effects. Community development and social disagreements dominate mining social effects research. Aryee (2016) analysed Ghana's mining industry's social consequences and CSR's potential benefits. Along with infrastructural and educational developments, benefit-sharing and stakeholder participation difficulties were noticed. These past studies detailed mining's complex economic, environmental, and social repercussions on Ghana's economy and its expanding mining sector's advantages and disadvantages.

2.4.1 Mining Resource and Theory Will Impact Society

The application of the resource curse hypothesis to the Ghanaian extractive industry allows for the analysis of potential hazards and the creation of mitigating strategies. Examining the social impact the anticipated societal repercussions of growth initiatives like extractive industries are examined using a method known as social impact assessment (SIA) (IAIA, 2018). We have a solid foundation for understanding how mining has impacted Ghana's economy thanks to these fundamental ideas and beliefs. While the concept of equitable growth concentrates on obtaining financial success while taking social and environmental variables into account, the "curse of resources" hypothesis places a particular emphasis on the dangers of drug consumption. Companies' social responsibility plays a crucial role in promoting environmentally responsible mining practices, and the assessment of social impact helps pinpoint and address the social effects of mining. Administrators, individuals involved, and mining entrepreneurs will be better able to manage Ghana's natural resources while advancing toward attaining equitable and sustainable growth by embracing the aforementioned principles and ideas.

2.5 Mining's Economic Impact

The mining sector has had a big impact on Ghana's economic development. Due in large part to gains in foreign exchange, investments, and ties to other economic sectors, the sector has significantly raised the country's GDP. Mining activity money has been crucial in fostering infrastructure growth and social service investment, both of which are essential for the advancement of the economy and the well-being of society. In addition to other developmental activities, these expenditures have aided in the development of public utilities, education and healthcare facilities, and transportation networks (World Bank, 2020; Aryee, 2016). Additionally, Ghana's industrialization and economic diversification have been sparked by the mining industry. The existence of the business has encouraged the expansion of related industries including manufacturing, construction, and transportation. The interconnection of the mining industry with other industries has increased employment possibilities and fueled global economic growth (Aryee, 2016). Ghana's economic expansion has also been aided by foreign exchange revenues from exports of mining products. Improvements are made to the country's standing in international trade, the state of its balance of payments, and the availability of resources for the importation of products and services supporting various economic activities (World Bank, 2020). Ghana's economy has benefited from the mining sector's backing of technological development and innovation. Modern tools, equipment, and knowledge are often needed for mining activities, which promotes the development and application of cutting-edge technologies. This technological transfer and its knock-on effects have the potential to increase overall productivity and competitiveness across all economic sectors (Aryee, 2016). It is crucial to keep in mind that the level of economic growth that mining contributes to might vary depending on a range of variables, such as commodity prices,

governmental regulations, and environmental sustainability. To provide long-term advantages for Ghana's economy and its people, mining requires careful management, strong legislation, and ethical standards.

2.6 Innovation in the Gold Mining Industry in Ghana

- We can increase the profitability and productivity of Ghana's gold mining sector by utilizing digital innovation. They can therefore be used to increase mechanization through automation, develop a more thorough awareness of the resource base, optimize material and equipment flow, improve failure prediction, and monitor performance in real-time.
- Our efforts to foster a respectful and safe workplace are motivated by innovation in balancing safety in the mining industry in Ghana, which includes developing a culture of care, promoting diversity, equity, and inclusion, and identifying and eliminating harmful behaviors like bullying, harassment, and discrimination that have a broader focus. While in the area of physical safety, we broadened our perspective to ensure that workers and contractors are shielded from all types of harm, including psychological. In response to growing awareness of bullying and harassment in the mining sector.
- There are five cutting-edge approaches to making the gold mining business more environmentally sustainable, and they are as follows.
- The greatest environmental dangers are associated with conventional mining methods like open pit and underground mining.
- Mining waste reuse.
- Eco-friendly machinery.
- Cleaning up Old Mines.
- Eliminating Illegal Mining.

III. METHODOLOGY

Deductive and inductive components are combined in the research methodology. In deductive studies, the investigation is guided by the current theory and presumptions. The gathered data is then used to support or challenge the hypothesis, assisting in its revision. In a nutshell, once the empirical findings of the research are compared to the selected hypothesis, the deductive technique may include an inductive strategy. The method of deductive reasoning appears to be consistent with the research design of the study. This is demonstrated by the research's utilization of existing ideas which include the resource enchantment hypothesis, Dutch sickness hypothesis, and mine ideas.

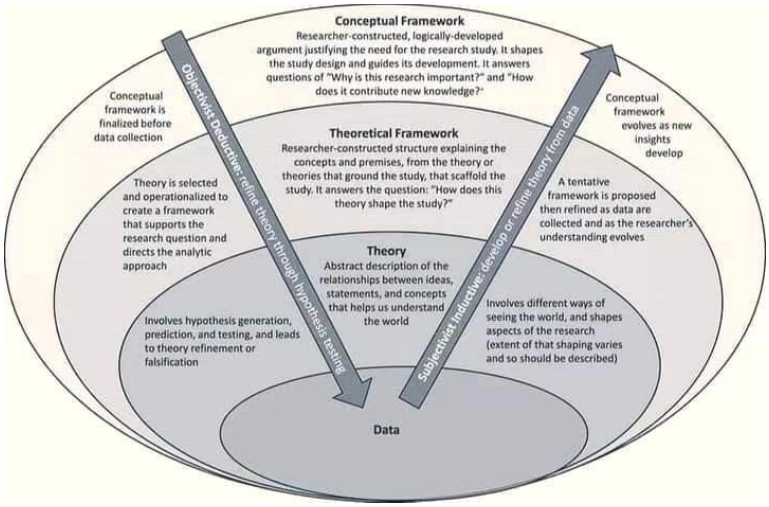

Fig.1:Different type of study we conducted

In this study, the consequences of mining on the Ghanaian economy from 1992 to 2020 were examined through a review of the literature. The study looked at how mining operations affected the economy, society, and environment to provide information to decision-makers, stakeholders, and academics.

3.1 Mathematical Model

Our research work is based on theoretical and empirical study. In our study, we employed a statistical approach for sampling all 110 survey respondents. By doing a case study, we use regression and descriptive statistics to examine the relationships between the variables to determine the tactics employed to strike a balance between

security, financial success, and environmental sustainability. This was used due to the unclear population.

$$n_0 = \frac{Z^2 pq}{e^2}$$

- n_n =Size of the sample,
- Z^2 = the desired confidence level is abscissa of the normal curve that cuts off an area at the tails $1 - \alpha$, l, e.g., 95%,
- $e$is the desired degree of accuracy.
- $p$is the estimated percentage of an attribute that the population possesses.
- $q$is $1 - p$.

Where;

- $Z\ score = 1.05$
- $p = 0.5$
- $q = 1 - p$
- $e = 0.05$

Therefore;

$$n_0 = \frac{Z^2 pq}{e^2}$$

$$n_0 = \frac{(1.05)^2(0.5)(0.5)}{(0.05)^2} = 110.25$$

The linear regression equation is:

$$y = \beta_0 + \beta_1 x + \varepsilon$$

Whereas;

Y represents what can be expected from the subject variable (y) in light of any factor in the independent variable (x).

$\beta_0$is the intercept, or the value of y that is anticipated when x is 0.

$\beta_1$regression coefficient

$X$is the independent variable (the one that we anticipate impacting y). ε is our estimate of the logistic statistic's estimation error, or how much it differs from our estimate?. With looking for the correlation parameter (β_1) which optimizes the prediction's aggregate error (ε) (Zou et al., 2003), linear regression discovers the best-fitting line through the data. Using this technique, each hypothesis was evaluated. The relationship between the uncorrelated variables as well as dependent factors was analyzed using logistic regression as well as correlation techniques. The adoption of OSH practices by smallholder coal miners was the dependent variable (y) in this section, and the independent variables (X) were sociocultural characteristics, common OSH concerns, managerial commitment, training, and demographic characteristics.

After gathering information and administration, the study began by generating descriptive data and analyzing possible difficulties with multicollinearity, heterogeneity, and oscillation. The suitableness of using random vs fixed impacts was subsequently assessed.

In order check the multicollinearity we use VIF, which is called variance inflation factor, the mathematical for calculating VIF manually is;

$$VIF_i = \frac{1}{1 - R_j}$$

Whereas, R_j is residual correlation regression.

In order to heterogeneity, we use the mathematical formula;

Mathematically, I^2 is expressed as $I^2 = {\tau^2}/{(\sigma^2 + \tau^2)}$, where τ^2 denotes the between-trial heterogeneity, σ^2 denotes some common sampling error across trials, and $(\sigma^2 + \tau^2)$ is the total variation in the meta-analysis.

3.2 Data Collection Methods

The Ghanaian EPA, Ghana's Chamber of Mining, and local stakeholders who are now gaining from social entrepreneurship projects were included in the research's population in addition to all of Ghana's continuously operating and publicly listed gold mining enterprises. We acquired further research information for the project. In the Republic of Ghana, 14 gold mining companies—10 of which are actively engaged in stock market trading—are working on the AKOBEN Initiative.

3.3. 1 Sampling and Sampling Procedures

Using the entire population sample method, we chose ten mining firms. The complete research population was taken into account in the sampling procedure by using a complete population sampling (Leedy & Oxford, 2015). The mining businesses were selected because they had offices in Ghana that pursued gold being an asset. We needed to select samples from a large enough pool of organizations to undertake the data analytics for the project. Because this study used archive data, we could access information on ten gold mines, which we identified as a constraint while doing statistical analysis. With care, further analyses of the facts were created.

- *Data Analysis Procedures*

The study included basic arbitrary and intentional sampling approaches, in addition to a method for a descriptive study that focused on operations and mining for goldfield inspections. Additional sources of data, including journals, magazines, and the World Wide Web

were employed. Gold mining companies who agreed to take part in the research were approached. 110 people in all were questioned as part of the investigation. Targeted sampling was used to choose ten (10) employees, including two (2) each from the EPA, the Minerals Commission, the Forests Commission, the Wastewater and Water Resources Commission, and the Asutifi North District Congress. The 100 participants in the sample were chosen at random. The research team conducted interviews with key informants and field research, respectively, to collect information from significant sources and small-scale artisanal miners. The EPA, the Miners Commission, the Timber Commission, the Minerals and Water Sources Commission, and the Asutifi North Regional Assembly have all employed key informant interviews and surveys to learn more about their personnel. The people who responded as the most important informants were chosen through purposeful sampling.

To assure the reliability and fullness of the information that was obtained, the questionnaires and guide to interviews were sequentially numbered. Respondents' confidentiality and safety were ensured, thus they felt under no need to submit information. This was used due to the unclear population.

$$n_0 = \frac{Z^2 pq}{e^2}$$

- n_n =Size of the sample,
- Z^2 = the desired confidence level is abscissa of the normal curve that cuts off an area at the tails $1 - \alpha$, l, e.g., 95%,
- $e$is the desired degree of accuracy.
- $p$is the estimated percentage of an attribute that the population possesses.
- $q$is $1 - p$.

Where;

- $Z\ score = 1.05$
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- $q = 1 - p$
- $e = 0.05$

Therefore;

$$n_0 = \frac{Z^2 pq}{e^2}$$

$$n_0 = \frac{(1.05)^2(0.5)(0.5)}{(0.05)^2} = 110.25$$

As a consequence, the collection size for competent participants and inspectors selected for the study is 110. The Statistical Program for Social Science (SPSS 20.0) was used to purify, code, and evaluate the data. 2.3.

3.4 Test the Hypothesis:

Using correlation and linear regression, the research tested the subsequent assumptions:

= There is no connection between gold mining operations and common OSHA concerns.

There is no correlation between management's resolve and mining workers' acceptance of occupational safety and health standards.

The significance (alpha) levels of 10%, 5%, and 1% were used to evaluate each hypothesis. Confidence intervals of 90%, 95%, and 99% were also used. When the P-value is below the levels of statistical significance (alpha), the hypothesis test is considered statistically significant. For the findings to be regarded as statistically significant, the confidence interval must not include the conclusion of the null hypothesis (Greenland et al., 2016). According to (Sauro, 2015), the 90% confidence level is used as technological assurance when examining questionnaire data as well as a comparability because 90% confidence for a symmetrical assertion is equivalent to 95% confidence for a biased assertion. While the research used poll results, the 90% confidence level was chosen as commercial assurance in examining the miners' reactions. According to (Sauro, 2015), the 99% confidence level is usually applied for scenarios when a poor decision might result in harm or fatalities, and the researchers applied it since poor decision-making in the gold mining sector would contribute to fatalities or serious injuries. To guarantee an elevated degree of accuracy in the opinions of the smaller-scale miners, nearly each of the precious metals processing facilities in Ntotroso traveled to collect facts. Each of the provided hypotheses was tested using confidence ranges of 90%, 95%, and 99%, with corresponding significance (alpha) values of 10%, 5%, and 1%. Correlation analysis, a statistical technique, assesses the degree of association between prevalent health and safety problems and gold mining. When there is a strong correlation between several factors, there is a meaningful relationship between them. Consequently, it may be characterized by the examination of the intensity of an association using existing statistical data (Franzese and Iuliano, 2018). The approach described here is reliant upon linear regression analysis, a form of statistics used for describing the relationship between an intervention variable and any number of independent/explanatory variables. The research project utilized metrics to evaluate the relationship. The linear regression equation is:

Whereas;

Y represents what can be expected from the subject variable in light of any factor in the independent variable .

is the intercept, or the value of that is anticipated when is 0.

regression coefficient

is the independent variable (the one that we anticipate impacting .

is our estimate of the logistic statistic's estimation error, or how much does it differ from our estimate? By looking for the correlation parameter () Linear regression discovers the best-fitting line through the data. Using this technique, each hypothesis was evaluated. The relationship between the uncorrelated variables, as well as dependent factors, was analyzed using logistic regression as well as correlation techniques. The adoption of OSH practices by smallholder coal miners was the dependent variable in this section, and the independent variables were sociocultural characteristics, common OSH concerns, managerial commitment, training, and demographic characteristics. OSH dangers posed by ASGM operations in Ghana. The risks associated with gold mining in Ghana have been assessed and published, including the psychological, mental arbitrary, auditory, natural, chemical, and other risks.

IV. RESULTS AND ANALYSIS

Simple random and intentional sampling techniques were employed in the study, along with a descriptive research plan that concentrated on ASGM operating operations and on-site field observation. The internet, journals, and periodicals were employed as secondary data sources. We contacted ASGM operators who agreed to take part in the study. For the study, questions were asked of a total of 110 people. 100 participants for the study were chosen using simple random sampling, and ten (10) officers, including two (2) each from the Environmental Protection Agency, Minerals Commission, Forestry Commission, Water Resources Commission, and Asutifi North District Assembly, were chosen using purposeful sampling. The study used field surveys and key informant interviews to collect data from key informants and artisanal small-scale miners. The Environmental Protection Agency, the Minerals Commission, the Forestry Commission, the Water Resources Commission, and the Asutifi North District Assembly officials were interviewed as key informants using semi-structured questionnaires. Through deliberate sampling, the key informants' respondents were selected. Key informant interviews were carried out to gain additional knowledge of the perceived effects of artisanal and small-scale gold mining as well as the functions performed by these specific regulatory authorities in the research area. To determine the challenges miners faced when implementing OSH techniques, this data was acquired. However, the questions in the field survey were primarily concerned with how OSH regulations were being applied as well as common OHS problems related to small-scale mining operations. Primary data from ASGM operational sites were gathered by the study via a survey. The survey was broken down into two sections: (a) demographic information on the respondents; and (b) data on the causes and effects of accidents that occur while ASGM operations are in place. a) OSH improvement techniques and compliance levels; b) operational activities and OSH management systems for the ASGM business in Ghana. According to the scale, 1 stood for strongly agreeing, 2 for agreeing, 3 for neither agreeing nor disagreeing, 4 for disagreeing, and 5 for strongly disagreeing. Options for not at all, Very often, Often, Indifferent, Not often, and often were also available on the Likert scale. Self-administered questionnaires were used by us. The two sets of questions that made up the questionnaires had both closed-ended and open-ended inquiries. For the closed-ended questions, respondents had to choose from a variety of answers the one that best expressed their ideas. However, there were no more options for the open-ended questions. Responses from respondents were recorded or entirely expressed in writing. Respondents had enough time to carefully consider the questions before responding, ensuring that they gave truthful answers and answered questions as they understood them. Before beginning the whole question-asking process, pretesting was done to ensure the questionnaires were correct. The interview guides and questionnaires were serially numbered to ensure the correctness and comprehensiveness of the data collected. Respondents have the freedom to withhold information because their confidentiality and privacy are guaranteed.

Table 1Information about Respondent's Demographics

Variables	**Frequency**	**Percentages**
Gender		
Male	88	80.0
Female	22	21.0

Total	110	100
Age Distribution		
25	15	13.6
26-35years	56	50.9
36-45years	29	26.3
	10	0.10
Total	110	100
Level of Education		
No Education	38	34.5
Primary School	32	29.1
JSS/JHS	20	18.18
Technical/SSS/SHS	14	12.7
Tertiary/GCE 'O' Level	6	0.1
Total	110	100
Number of years in ASGM Operations		
	18	16.4
6-10 years	30	27.3
11-15years	40	36.4
16-20years	21	19.1
Total	110	100
Valid Mining Permit		
Yes	10	0.1
No	100	90.9
Total	110	100
Source of Funding for Mining Operations		
Individual Effort	21	19.1
Loan from Financial Institution	24	21.9
Family	10	0.1
Investors gold dealers	55	0.50
Total	110	100

4.1 Industry's Daily Operations

Table 2 lists the conclusions about ASGM operational activities. 4.5% of those surveyed possessed active licenses or permits. This implies that the bulk of those who responded and were running ASGM did not possess any valid licenses or permits. (McQuilken and Hilson, 2016b)(), according to which the majority of artisanal miners lack operating money and the necessary licenses to engage in mining. According to Table 2, which details the techniques respondents used to acquire land for ASGM operations, 59% of them obtained it from family members. Additionally, this is the most straightforward method of acquiring land for ASGM operations at Ntotroso. As a result, the vast majority of family estates now have ASGM businesses. This is in line with the findings of (Agariga et al., 2021), which demonstrate that the forest cover has been replaced by a variety of land uses, such as open vegetation, mining, settlements, etc. The other respondents (Table 2) acquired the land from either chiefs or mining companies. This backs up the judgment made by chiefs in 2019 and documented by Boafo et al.

Table 2ASGM's operational activities in Ghana

Variable	Frequency	Percentage
Have you gotten a valid permit		
Yes	10	0.1%
No	100	99.9%
Total	110	100%
From whom did you acquire land from ASGM operations		
Family	60	54.54%
Chiefs	36	32.73%
Mining companies	14	12.73%
Total	110	100%
Do you have supervisors		
Yes	80	72.3%
No	30	27.3%
Total	110	100%
Do you use explosives		
Yes	90	81.82%
No	20	18.18%
Total	110	100%
Description of the type of Mining		
Both surface and underground	110	100%
The main mineral produced by Gold	110	100%

Confidence Interval 95%

Traditional leaders are responsible for supervising mined customary areas, particularly stool lands, and they should be notified before the start of mining and paid for their assistance. The Forestry Commission's desk staff claims that in addition to purchasing land from individuals, families, or chiefs, the Commission also plays a crucial part in making sure that the territory used for ASGM activities is not close to or within any forest reserves. However, if the ASGM activity occurs outside of a forest reserve but may have an influence on valuable commercial trees, the commission will provide clearance for the removal of the trees that are located within a mining concession. According to the Water Resources Commission, neither the ASGM site nor its operations significantly affect any significant water body or resource. Information on the respondents' supervisor status is provided in Table 2, which reveals that 75.4% of them had supervisors. These managers—frequently referred to as "ghetto leaders"—direct a group of miners within a "ghetto" (mine). The majority of respondents employ explosives in their regular activities, as shown by Table 2 as well. This supported earlier studies that showed explosives are used when the ore is hard and difficult to shatter (Mcwhorter et al., 2017). The study also made an effort to divide mining into surface mining and underground mining. Instead of limiting themselves to one sort of mining, all of the respondents engaged in both (Table 2). ASGM miners operate in both surface and underground mining.

4.2 OSH Risks

Associated with ASGM operations in Ghana Physical, psychological, ergonomic, mechanical, acoustic, biological, and chemical risks are those connected to Ghana's ASGM sector.

4.2.1 Physical Hazards

Dangers to the body According to Table 3, a result, the mean reaction value in ASGM operations is only 3.59 because there are so few fire outbreaks. Observations from the field survey show that combustible goods like fuel

(diesel and gasoline) are often held in smaller quantities within the ASGM sector as opposed to open mining sites. This explains the main cause of the ASGM industry's relative lack of fire breakouts. Additionally, the mean of the ASGM sector demonstrates that explosions at abandoned sites are not common. This may be explained by the fact that when explosives are utilized, they are not frequent. According to the research, falls from great heights are a prevalent risk in the ASGM sector. The average reaction as a result was 2.08 (Table 3). This is consistent with the findings of Nakua et al. (2019), who discovered that falls and slips are among the injuries sustained while working in the ASGM mining industry. In the ASGM sector, collapsing mine pits and stranded individuals are common issues. In this instance, the typical answer value was 2.13 (Table 3). This validates the findings of (Nakua et al., 2019) that underground miners in ASGM frequently run the risk of pit collapse due to their inability to erect concrete walls and pillars to avoid rockfalls and pit collapse. Another physical concern mentioned in the paper is flooding. Table 3 demonstrates that during the rainy season, flooding occurs at ASGM sites. This is consistent with the results of a study by Donoghue from August 2004 that identified flooding of underground pits as a significant contributor to fatal injuries among miners. As a result, operations frequently come to a standstill, and pumping the water may take several days. The mean reaction values for miners exposed to extreme heat both underground and from the sun were 1.86 and 2.16, respectively (Table 3). Since ASGM can't erect shelters that completely enclose a site, many miners are subjected to intolerable amounts of solar heat. The investigation as a result showed that miners use handmade plastic lines to connect deep underground tunnels to temporary ventilators known as "blowers" (see Fig. 2). These improvised "blowers" hardly blast out enough air as the miners continue to toil in the sweltering heat. The study also discovered that electrocution happens frequently (Table 3). The majority of mining locations were discovered to have electrical lines that were improperly connected and may electrocute at the slightest contact.

Table 3 Hazards

Hazards	Mean	S.D.
Physical Hazards	3.49	1.13
Fire outbreaks occur at construction sites	3.29	1.20
Abandoned areas often experience explosions	2.10	1.14
Workers who are walking about an unfenced hole or climbing up or down in one experience falls.	2.10	1.31
A pit caved in because there was insufficient earth support underground.	1.45	0.68
Sites where small-scale mines were being operated were flooded during the rainy season.	1.78	1.12
During the day, employees are exposed to too much sun.	2.20	1.26
Workers are subjected to extreme heat underground	2.87	1.29
In Ghana, ASGM electrocutes workers while conducting operational tasks.	2.40	
Mechanical Hazards		
At a mine site, excavators and other mobile machinery run over workers.	3.45	1.23
The whirling elements of machinery cause abrasion to workers	2.20	1.24
Some perils could lure in or trap you	2.09	1.12
There are problems with cutting and shearing while using equipment in Ghana's ASGM.	3.10	1.18
Noise Hazards		
During blasting, drilling, milling, and other operational tasks involving the use of power plants and heavy equipment, workers are exposed to a high level of noise.	1.62	1.10
Artisanal Mining in Ghana as a Whole	1.61	
Chemical Hazards		
During operation, workers are exposed to hazardous chemicals	1.98	1.13
Smoke from diesel operating equipment's total ASGM in Ghana has accumulated.	2.45	1.09

Biological Hazards		
No nose mask or guard is used, thus employees are exposed to dust at work.	1.34	1.09
Fungi infection exists because workers are required to remain barefoot in still water while washing gold.	2.03	1.11
Because of the remoteness and stagnant water at the sites, ASGM in Ghana employees are subject to mosquito bites.	1.98	1.23
Ergonomic Hazards		
Employees are involved in heavy lifting	1.34	1.06
Workers' knee injuries result from carrying large loads	2.31	1.94
Shoulder issues are prevalent among workers	1.78	1.51
Workers experience back and waist pain	2.31	1.78
Uncomfortable working images are maintained during the ASGM operation in Ghana	3.01	1.98
Physiological Hazards		
Employees put in a lot of overtime	1.98	1.23
After putting in long hours at work, employees have appropriate interactions with their families	3.09	2.98
There is violence among the workforce at all ASGM facilities in Ghana.	3.10	1.76

4.2.2 Mechanical hazards

Table 3 displays the study's findings on mechanical dangers. The findings (mean = 3.41) demonstrate how uncommon it is for ASGM staff members to be struck by trucks, excavators, or other mobile machinery. This is because simple tools and equipment were used. Trucks, excavators, and other mobile equipment may be utilized, but not when numerous machines are running at once and could crush or run over people. The mean response value for abrasion, which was 2.13 (see Table 3), indicates that abrasion concerns are widespread. According to a field evaluation, abrasion often occurs in the rotating parts of the machinery and equipment used in mining operations. Small crushers, in contrast, are employed in ASGM and don't injure anything because they can readily pull in and trap material. Although cutting and shearing risks are listed among the mechanical hazards in the survey, ASGM enterprises do not face them, as evidenced by their mean response value of 3.09 (see Table 3). The mechanical risks found in the study were consistent with those found in (Abbasi, 2018), which showed that mining requires the use of machinery, tools, and equipment for a variety of tasks. This machinery, tools, and equipment all have the potential to sever, cut, crush, strike, or stab anyone in the machine's path because of their moving or spinning parts, sharp edges, and heated surfaces.

4.2.3 Noise

The study found that noise was an issue, and the mean response value of 1.71 (Table 3) demonstrates how pervasive it is. The primary causes of excessive noise in ASGM activities may be the machinery and equipment (see Fig. 3). The fact that large machinery is needed for ore drilling, blasting, transporting, sorting, and crushing supports Hermanus's (2007) conclusion that noise is a significant problem in the mining industry.

4.2.4 Chemical Hazards

The mean reaction value for dangerous substances was 1.77 (Table 3). According to the results of the field investigation, Mercury and Med are the key ingredients used in ASGM. Because miners spend longer time underground, they breathe in poisonous materials like mercury, which are harmful to their health even if their toxicity is not immediately apparent when they come into contact with skin. The study also found that a key source of chemical hazards faced by miners in ASGM was smoke buildup from diesel-powered equipment. The accumulation of smoke from diesel equipment suggests that it is frequently observed with a mean response score of 2.56 (Table 3). The field investigation indicated that the primary sources of smoke that miners inhaled were diesel-powered equipment such as the Chinese-made crusher ("chan fan"), compressors, excavators, and power plants. The majority of miners experienced vertigo after spending a lot of time around diesel-powered machinery, according to the field survey. The finding that miners exposed to diesel particulate matter (DPM) developed cardiovascular

dysfunction, eye and nose irritation, headache, nausea, and asthma is consistent with the findings of the Utembe et al. (2015) study.

4.2.5 Biological Hazards

Dust (mean = 2.01) continued to be a major biological hazard in almost all ASGM operations (Table 3), particularly during overburden removal, blasting, ore transportation, crushing, and even ore washing. According to a 2016 study by Bansah et al., dust is created in mining during ore drilling, ore blasting, crushing, and grinding. Since most miners do not wear masks or nasal guards, they frequently run the risk of being exposed to dust. An additional biological risk discovered was fungi infection (mean = 2.3). (Table 3), illustrating how mining-related fungal infections are a common problem for miners. The stagnant waters that are frequent at mining sites make this condition hazardous. This is in line with research (Abbasi, 2018), which demonstrates that biological risks are connected to mining activities as a result of unhygienic working conditions. Therefore, the health and safety of mineworkers are significantly impacted by limbs subjected to biological dangers such as snakebites and injuries, and exposure to bacteria, viruses, fungi, and blood-borne illnesses. Miners also experience a high rate of mosquito bites (mean = 1.61) due to the standing water and distance between mine sites (Table 3).

4.2.6 Ergonomic Hazards

When objects are lifted without assistance, lifting heavy weights (mean = 1.93) is an occupational risk that frequently affects miners (Table 3). In addition to these new types of injuries, miners also experience improper posture while working and knee, shoulder, waist, and back problems during ASGM tasks (see Table 3). Beth's (2018) findings that protracted digging, uncomfortable postures, bending down, and lifting heavy goods over long distances can all cause severe and chronic back pain were supported by the study.

4.2.7Psychological Hazard

Table 3 (Mean = 1.98) shows that miners worked a lot of overtime. The findings of this study are congruent with those of (Abbasi, 2018), who discovered that the lengthy workweeks typical of the mining sectors can occasionally lead to psychological dangers in the mining industry. Additionally, the results demonstrate that respondents frequently communicate positively with their families, as evidenced by the mean answer value of 2.54 for adequate engagement between respondents and miners' families (Table 3). These results refute the claim made by (Abbasi, 2018) that the major psychological risks for miners are isolation and loneliness. The prevalence of violence among miners is considerable (mean = 2.5), as seen in Table 3. Due to the rigorous and challenging nature of their work, it may be assumed that miners were using narcotics at the time. Bullying and mobbing were mentioned as two psychological issues that miners must cope with in the study (Abbasi, 2018). Pit invasions might also have a role in miners acting violently. When it is determined that a group of miners' pit has struck the gold-bearing ore that is rich in gold, invasions take place. When the owners aren't there, unauthorized individuals frequently break into the pits or infiltrate them to steal from them. Because of the regular fighting among the miners, the areas are dangerous.

4.3 Implementation of OSH Procedures by ASGM

4.3.1 Safety training

The mean response value for the question of whether the ASGM industry has a well-established safety protocol was 1.59 (Table 5), indicating that it does not. Therefore, the existence of safety measures has little impact on the adoption of OSH in the ASGM industry. This can be a result of ASGM management's general lack of consideration for developing safety measures. There were no formal safety procedures in place at almost all ASGM locations. If safety protocols are absent from the ASGM locations, they cannot affect the miners' adoption of OSH practices. For safety measures, a mean response value of 3.23 (Table 5) was discovered, indicating indifference. Since the majority of miners were illiterate and had no awareness of safety procedures, they were unable to determine whether a safety routine was necessary. This supports the conclusions of (Stephens, 2016), The mean response scores of 1.74 and 1.56, respectively, in Table 4 indicate that workers receive enough training on safety practices and how to use PPE, as well as follow-ups and refresher safety training. This demonstrates that teaching in personal protective equipment (PPE), training in safety procedures, and follow-up and refresher safety training do not affect the adoption of OSH practices by miners. The field survey found that virtually any of the venues looked at offered their personnel pre- or on-the-job training. This might be the outcome of miners believing they don't require any specialist training and that learning and training occur on the job. The mean response values for regularly recognizing and reporting safety issues as well as evaluating and resolving issues that are detected promptly were 2.07 and 2.5, respectively (Table 4), indicating not frequently. Therefore, these variables won't typically have an impact on how OSH techniques are adopted in ASGM. The average response in Table 4 for how frequently facilities and equipment are maintained before and after usage was 2.33. This shows that the ASGM doesn't always perform adequate machine and equipment repairs.

Additionally, it was said that repairs are only performed to tools and machines after they have entirely failed and are unable to be used to finish a task. Additionally, because normal maintenance on apparatus and equipment doesn't happen very often, it won't have a big impact on how frequently ASGM's miners practice OSH.

Table 4 Safety Training

Safety Training		
A tried-and-true safety procedure is in place.	1.49	0.59
The safety protocol is appropriate.		0.59
The usage of personal protection equipment and safety procedures are adequately taught to employees.	3.01	1.10
Enough follow-up and refresher safety training is offered.	1.36	0.85
Safety issues are often recognized and reported.	2.04	0.69
Identified safety concerns are carefully evaluated and handled.	2.3	0.88
Before and after me, facilities and equipment are repaired.	2.11	0.71
Overall mean	1.99	
Cultural and Social Issues	2.22	0.74
My family is very important to me, thus I strictly follow safety regulations.	2.99	0.82
I support OSH because my community has designated me as a safety ambassador.	4.058	1.12
Overall mean	2.23	

Table 5 Correlation Analysis

	Mean	S.D.	1	2	3	4	5	6	7
Physical Hazards	2.36	0.27	0.99						
Mechanical Hazards	2.82	0.52	0.21	0.99					
Noise	1.62	0.62	0.28	0.21	0.99				
Chemical Hazards	2.16	0.23	0.22	0.28	0.22	0.99			
Biological Hazards	1.89	0.23	0.41	0.22	0.314	0.164	0.99		
Ergonomic Hazards	2.22	0.36	0.22	0.41	0.436	0.644	0.544	0.99	
Psychological Hazards	2.24	0.54	0.42	0.22	0.245	0.512	0.625	0.610	0.99

4.3.2 Social and Cultural Problems

The findings (Table 5) demonstrate how socio-cultural factors affect how well the ASGM at Ntotroso miners embrace OSH. The average response value was 4.58, which indicates that respondents regard their family so highly that they take safety concerns seriously. Because they care deeply about their families and wish to live as long as possible in excellent health, the respondents commonly say that they take safety issues seriously. Because of this, even though their work is exceedingly dangerous, they take all required procedures to ensure the safety of their operations. This, which is an important predictor, has a substantial impact on how responders embrace OSH techniques. The mean response value for the claim that "WE take OSH seriously because my community has appointed me as a safety ambassador" was 3.03, which is considered indifferent (Table 4). Because the majority of them had not been chosen to serve as safety ambassadors in their communities, the respondents to the field survey expressed uncertainty. Does not, therefore, represent a substantial factor influencing the respondents' adoption of OSH.

Table 6: Relationship between safety education, sociocultural issues, and OSH practices adoption by miners.

OHS practices	Coefficient	Std. Error	T	Sig
Safety Instruction	0.286	0.025	3.734	0.000
Social and Cultural Problems	0.259	0.0212	3.087	0.000
Con	1.643	0.357	5.052	0.000

4.4 Sociocultural Factors and Safety Education On ASGM Miners' Adoption of OSH Practices

We evaluated the connections among safety training, sociocultural concerns, and respondents' adoption of OSH practices. Safety Training and responders' adoption of OSH practices are positively correlated, as shown in Table 5. The significance level for this positive connection is 0.01. This indicates that responders who receive more safety training are more likely to adopt OSH practices. According to Table 5, there will be a 2.78% rise in respondents' adoption of OSH practices for every 10% more safety training provided. Additionally, the adoption of OSH techniques by respondents was positively correlated with socio-cultural difficulties at a significant level of 0.01. In addition, a rise in socio-cultural concerns will cause respondents' adoption of OSH practices to rise by 2.19%. This might be explained by the importance respondents place on their families and relationships. They place a high importance on their family and will do everything in their power to provide for them. So that they can take care of others, they embrace OSH practices to stay healthy and powerful. The alternative hypothesis (), which asserts that there is a positive connection with a 99% confidence interval between safety training, sociocultural factors, and the adoption of OSH practices among miners in ASGM, is accepted in place of the null hypothesis ()).

4.5 Sustainability

These sustainability elements are seen as interconnected and should work in harmony because a company cannot compensate for a poor performance in one area with a fantastic performance in another (Viveros, 2016). The phrases "sustainability" and "sustainable development" are used interchangeably in this study to refer to long-term business strategies- and short-term scope to satisfy both current and future social expectations. The empirical data, discussion, and theoretical framework would, however, consider these two difficulties since the study analyzes solutions for social and environmental sustainability.

4.6 Social Responsibility

Due to the underlying themes in social sustainability) mapped the definitional bounds to include the following: "Development sustainability" (a) takes into consideration basic requirements, the growth of social capital, justice, equity, and other challenges; "Bridge sustainability" (B) discusses behavioral changes; (C) discusses how people actively embrace or reject such changes; and (D) discusses the preservation of socio-cultural qualities in the face of change (or what can be sustained). The aforementioned idea provides a framework for social sustainability that considers the necessity for growth, the preservation of social capital, and collaborative relationships with stakeholders who have a substantial impact on changes and transformations (Viveros, 2016). Using this more comprehensive paradigm for social sustainability, it examines how large-scale mining companies deal with societal consequences before, during, and after mine closure.

4.7 Sustainability in the Environment

To stop the loss of biological diversity as a result of our actions, it also calls for measures. The management of "waste rocks, tailings, acid mine drainage, airborne dust, and other contaminants, which are deposited on land, in the air and water" is crucial to the mining industry's environmental sustainability, according to K. Söderholm et al. (2015). For environmental sustainability in mining, climate change, biodiversity, and water are essential, claim Tost, Hitch, Chandurkar, Moser, and Feiel (2018). The following explanation emphasizes the relationship between human efforts to meet needs and initiatives to protect or improve biodiversity, water quality, and ecosystems, demonstrating how adaptable humans are to living in a dynamic balance with the environment. The aforementioned definition is used in this study to understand how large-scale mining operations preserve and replenish biological variety in the sense indicated by the environmental effect categories.

4.7.1 The Sustainability of the Environment

Some of the key environmental consequence categories include changes in biodiversity, freshwater use, acidification, ozone depletion, chemical pollution, and climate change (Dong &Hauschild, 2017). The literature also offers a variety of benchmarks or metrics for evaluating environmental sustainability. The monitoring of resource usage efficiency, including emissions, byproducts, and performance are two essential areas to

focus on, Effect indicators (calculate a company's influence on the environment, worker health, and occupational injuries), supply chain management, and supply chain sustainability. These definitional criteria and indicators for environmental sustainability give a framework for assessing and understanding the effects of corporate operations and sustainable efforts (See Figure 5).

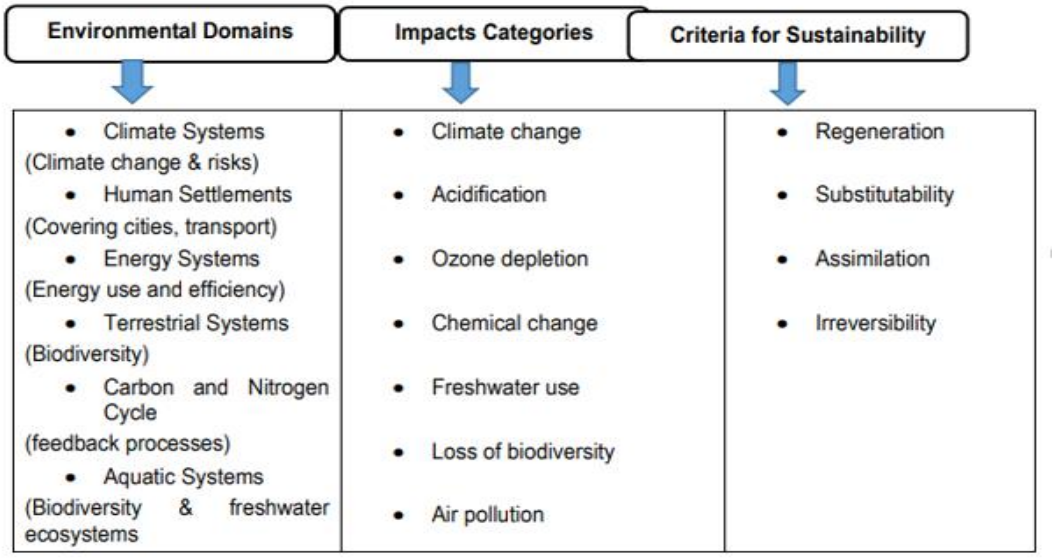

Fig.4 Environment's domain, effects, and sustainability

4.7.2 The Sustainability of the Economy

To improve a company's financial position and increase earnings, the internal component of economic sustainability focuses on using the concepts of effectiveness and efficiency in investments. Long Climate Systems & Murphy (Climate Change Risks) Energy systems (energy efficiency and consumption)

- Biodiversity in Terrestrial Systems
- The Nitrogen and Carbon Cycle (feedback mechanisms)
- Aquatic Systems: Freshwater Ecosystems and Biodiversity
- Human Settlements (including Transportation and Cities)
- Examples of environmental issues include acidification,
- Ozone depletion,
- Chemical change,
- Freshwater use,
- Biodiversity loss,
- Air pollution,
- Regeneration,
- Substitutability,
- Assimilation, and Irreversibility.
- Sustainability criteria and categories for environmental impacts.

This aspect of economic sustainability shows that consumers are more concerned about how sustainability will affect them personally than they are about a company's profits or financial performance. The economic aspect of sustainability has also drawn a lot of attention in studies on how companies increase their financial performance or look for a competitive edge (Kim, 2018). According to a similar statement, "Enterprise decision-makers naturally focus on the economic pillar of sustainability" (Hutchins, Richter, Henry, & Sutherland, 2019, p. 687). Up until recently, it was the only part of sustainability that had received attention. In addition, although the economic element of sustainability predominates, a study conducted in the metals sector by Armindo, Fonseca, Abreu, and Toldy (2019) suggests links between the various components of sustainability. However, the literature on mining shows that, despite stakeholders' primary focus on social and environmental issues, businesses still give economic sustainability a high priority (Rodrigues & Mendes, 2018). This study only considers social and environmental actions to address consequences. About the extraction of nonrenewable natural resources, sustainability is discussed in the section that follows.

4.8 Mining Environmental Sustainability

The majority of studies on sustainability in the extractive industries have focused on environmental issues, impacts, and frameworks as well as the management of the inherent risks associated with mining, according to Mensah et al. (2015), and numerous other studies. Several scholars, such as Schaltegger, Hörisch, & Freeman (2019), assert that mining firms' concerns about the consequences on the environment were ultimately what prompted them to accept sustainability as a broad phrase. Accordingly, "waste rocks, tailings, acid mine drainage, airborne dust, and other contaminants, which are deposited on land, in the air, and water" are listed as some of the negative consequences of mining on page 130 of their report by K. Söderholm et al. (2015). Tost et al. (2018) claim that to keep the environment sustainable, mining is highly reliant on elements like water, biodiversity, and climate change (see Figure 2.1).

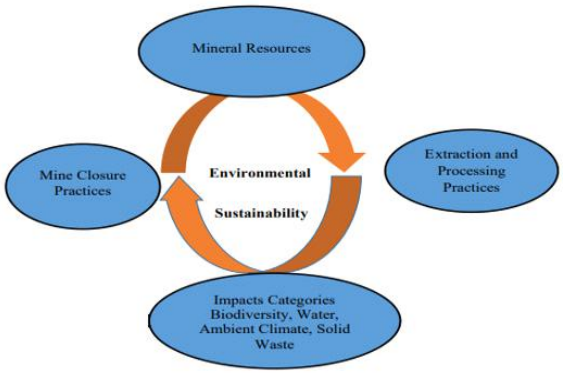

Fig.5 Environmental sustainability and mining in the landscape

Additionally, ecological quality is sustainably improved by environmental sustainability, which also incorporates techniques for reducing the negative consequences of mining (Tost et al., 2018). In particular with large-scale or international mining businesses, these environmental sustainability plans also involve innovative technology and resource efficiency methods (Barkemeyer et al., 2015b. Therefore, environmental sustainability in developing nations continues to be significantly hampered by ambient pollution, deforestation, chemical seepages, and biodiversity loss brought on by mining activities (Mensah et al., 2015; UNDP & UN Environment, 2018). Plans for environmental sustainability also include measures to mitigate effects after mine closure due to the serious hazards connected with leaving behind lasting effects. Even though trial-and-error techniques are most frequently used, mine closure land rehabilitation typically includes strategies for biodiversity restoration and ecosystem functioning linked to revegetation, species selection, and management of biological invasion. In contrast to the initial level of flora diversity and concentration, the process of reintroducing species is haphazard, and the amount of vegetation grown after a mine closes is always far less. However, because laws have a significant impact on mining enterprises' sustainability practices, national variations in environmental legislation may evoke different reactions depending on the institutional structure. For example, K. Söderholm et al. (2015) observe that "regulation also tends to vary from country to country depending on public policies and industry practices" about mine closure and rehabilitation. This article investigates how large-scale mining corporations adhere to environmental sustainability principles within the institutional framework, regulatory framework, and industry-led self-regulation activities of Ghana.

4.9 Ghana's CSR and Sustainability Initiatives

This section reviews studies on Ghana's mining industry's social and environmental sustainability strategies. Since the mining industry's social sustainability methods are usually part of CSR (Essah & Andrews, 2016), this section will also analyse them in Ghana. Social and environmental sustainability in developing nations defines a company's CSR operations, according to the literature. Thus, this section examines Ghana's large-scale mining sector's sustainability and CSR. Sustainability in South American mining has been studied (Loayza & Rigolini, 2016; Viveros, 2016). Thus, this part analyses sustainable implementation qualities using the latest research. As to Agyemang, Agyemang, Ansong, and Ansong (2017), CSR is new to the national institutional landscape but has gained popularity, especially in business. Businesses in banking, mining, and telecoms have adopted the idea by following essential statutory requirements (Agyemang et al., 2017). Oppong (2016a) says CSR initiatives often improve children, the environment, health, social entrepreneurship, and sports. This calls into question your sustainability understanding. Some of Ghana's environmental and social sustainability programmes exceed their CSR or sustainability implementation level, as shown in Table 2.4. Ghana may employ a lot of hydropower, which minimises greenhouse gas emissions. Large enterprises voluntarily disclose their energy use to global reporting organisations like the Global Reporting Initiative and ISO 14001. Table 2.4 shows that sustainability problems must be addressed during the mine's operating period upon closing. To meet Ghana's Minerals and Mining Act, 2006 (Act 703)'s minimum standards, land restoration, reforestation, and chemical spill avoidance are social sustainability initiatives

(Oppong, 2016a). Social sustainability, a developing term, varies from CSR owing to its broader conceptual similarities. Ghana may overemphasise CSR implementation as self-regulatory, which may explain certain sustainability difficulties. Ghana's social sustainability efforts, according to Andrews (2016), are fragmented CSR programmes that contradict sustainable actices. CSR programmes prioritise physical initiatives above social sustainability (tangible and intangible) after mine closure owing to the operational implications of mining. According to Andrews (2016), voluntary CSR programmes threaten social sustainability in Ghana's extractive economy. Social sustainability may involve volunteer initiatives, mining-induced displacement legislation, development partnerships, and regulatory compliance processes. Multinational companies' CSR agenda limits mining stakeholders' capacity to challenge large-scale mining operations (Ross, 2017). In mining-related social problems, the state and major mining firms often oppose impacted communities and civil society organisations (Tetreault, 2020). The institutional framework of developing nations negatively impacts managerial cognition, or how managers make sense of their environment, which threatens mining regions' long-term viability. Ghana's sustainability efforts prioritise land restoration, impact reduction, and community growth. The usual CSR method for neighbourhood protection is also criticised in this study. The poor institutional structure that limits compliance monitoring and regulatory enforcement is the main cause of Ghana's sustainability implementation problems (Andrews, 2016). Thus, multinational mining companies' social sustainability strategies are more significant. The following observations provide a framework for studying social sustainability theoretically and empirically.

Table 7 Domains for Environmental and Social Sustainability

Mine Lifecycle	Environmental Sustainability
Operational Phase	**Biodiversity** • Fauna and Flora **Water** • Quality and Quantity **Ambient Climate** • Air pollution • Noise pollution **Tailings Storage Management** • Chemical pollution/seepages **Energy Intensity** • Emission/greenhouse gases
Mine Closure Phase	**Lands/Biodiversity Restoration** • Vegetation regeneration potential • Animal species Richness/Diversity • Plant species richness/diversity • Habit diversity • Decreased forest land area **Water Bodies /Soil** • Destroyed or sedimented water course (surface water) • Underground water sources • Contaminated soil

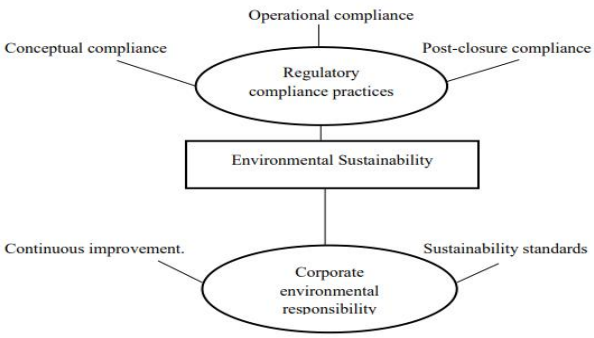

Fig.6 Environmental sustainability techniques' main topics and sub-themes Operational conformity

As previously said, mining poses significant hazards to the sustainability of the environment while it is still in operation, and managing the environmental effects of mine closure in developing nations is still very difficult. This led to the mention of "waste rocks, tailings, acid mine drainage, airborne dust, and other contaminants, which are deposited on land, in the air, and water" as examples of such mining consequences (K. Söderholm et al. 2015, p. 130). Large mining firms conduct sustainability initiatives to reduce these negative environmental effects throughout the mine's life. Although mining firms assert that their operations are beneficial to the environment, little is known about how they are addressing the short- and long-term effects of their operations. The sustainability programs that big mining corporations have implemented

to mitigate the damaging environmental effects of their operations in Ghana are examined in this chapter. To depict the main themes and sub-themes that arose from the data, thematic networks in two different implementation types are used. These sustainable practices and self-regulatory initiatives have led to these eco-friendly actions. The results presented in this chapter are set against the theme network in Figure 6. Highlighted are the key issues related to the causes that support environmental sustainability, while the sub-themes focus on how large businesses offset their consequences.

4.10 Practices for Environmental Sustainability

Selected large-scale mining companies have been profiled in this area to address environmental effects on water (quality and quantity), biodiversity, ambient climate (air and noise pollution), and soil quality. According to the statistics, impact reduction is the main goal of the environmental sustainability practices of the companies used as examples. Two crucial tools for doing this are strategies for regulatory compliance and corporate environmental responsibility. The findings demonstrate that environmental sustainability methods are applied at all stages of mining development, including pre-operational, operational, and post-operational stages. The sections that follow provide further detail on each organizational area for the methods of managing environmental effects (Figure 4.1). The table below (Table 4.1) provides a full examination of Ghana's environmental sustainability practices for controlling the consequences of mining throughout a mine's lifecycle.

Table 8 Implementing Environmental Sustainability in Ghana

Environmental sustainability practices (ESP)	Strategy	Requirement	Objective
Regulatory compliance practices 1. Conceptual	Scoping report, Environmental impact assessment,	Environmental permit, mining license	Impact mitigation
2. Operational	Compliance monitoring	EMP certification	Impact prevention
3. Post-closure	Environmental management plan (EMP)	Closure certification	Land reclamation
Corporate environmental responsibility 1. Global sustainability standards	Sustainability reporting, environmental audits and certification	Legitimation and social license	Standardization
	Environmental charter/policy	Perceived ethical obligation	Ethical and strategic motivations
2. Continuous improvement			

4.11Environmental Sustainability Obstacles

To address the ecological impact requirements, which include those for ambient air quality, pollution avoidance, water and soil quality, biodiversity, and terrestrial conditions, environmental sustainability practices work to adhere to the recommendations in section 4.3. However, both the case companies chosen for the interviews and the other stakeholder groups were able to identify key themes about the shortcomings in resource governance and effect mitigation that are the principal obstacles to environmental sustainability (Figure 6). The two main problems are further divided into two sub-themes, which are deficiencies in regulatory and compliance monitoring and deficiencies in proactive and residual mitigation, as shown in Figure 6. About these themes and their sub-themes, more information is provided in the section that follows.

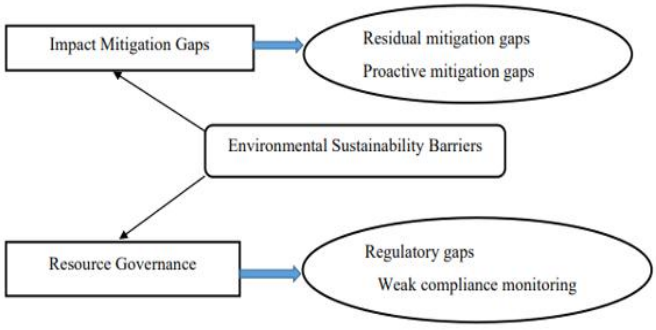

Fig.7 Implementation Challenges for Environmental Sustainability

V. CONCLUSION

Finally, we summarize the findings of our study as Gold mining, which is rapidly expanding and widely practiced throughout Sub-Saharan Africa, is an important source of earnings for a large number of people in the regions where it is conducted. Nevertheless, regardless of this acknowledged perspective, the extraction of gold presents several challenges to the individuals who partake in it, with the well-being and security of laborers being especially important. Our investigation's goal is to look at the Occupational Safety and Health (OSH) policies in Ghana's gold mining sector and reveal any flaws so that important stakeholders and authorities are aware. The overall findings of this study offer a thorough grasp of the health issues in Ghanaian gold mining villages. The research field employed a statistical approach for sampling all 110 survey respondents. The research revealed the absence of OSH system oversight, with mechanical, physical, chemical, biological, auditory, ergonomic, and psychological hazards constituting the majority of accident causes. This results in harm, deaths, and productive absences. In addition, the research revealed a lack of OSH policies and methods for improving gold extraction, for which it found no reference. In our research, we additionally deal with the way we govern the gold extraction process as it alters the countryside, as well as the economic viability and ecological conservation of Ghana. These results indicate that there have been occupational safety and health breaches in the gold rushes in the research region. Consequently, the investigation recommends striking a balance between protection, economic success, and preservation of the environment. A greater prevalence of protective clothing and footwear as well as periodic incorporation of aerial vehicles into governmental evaluations of the gold extraction industry are among the conceivable objectives for achieving occupational safety and health standards, boosting Ghana's financial health, and ensuring ecological sustainability.

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