JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Impact of Mining Practices on the Socio-Economic and Environment in Eastern Province,

A Case of Musha Mines

Author: Mr. SIBOMANA Jean d'Amour (Department, Environmental Economics and Natural Resource Management, University of Lay Adventist of Kigali [UNILAK])

Co-author: Dr. SIBOMANA Eric (Department, Environmental Economics and Natural Resource Management, University of Lay Adventist of Kigali [UNILAK])

Abstract:
Background*: This study highlights the environmental impacts of mining near MUSHA Mines, emphasizing the importance of a safe environment for human health. The study looked into the effects of mining practices on the environment in Eastern Province, Rwamagana, particularly on the communities that are close to the mines. The objectives of the study were: to evaluate how mining operations affect the environment in the eastern province, particularly in the areas where the Musha mines are located, to evaluate the negative effects of mining in Eastern Province on the environment, particularly on the communities surrounding the Musha mines and to evaluate the relationship between mining practices in MUSHA mines and the environmental degradation and health problems. The findings will be beneficial to the Government of Rwanda, mining policy makers, miners, mining companies as well as the Rwandan communities around mines.*
Materials and Methods: *The study utilized a descriptive survey design, targeting 400 respondents, including miners, mining company authorities, and nearby communities, with 39% males and 61% females. Purposive, stratified and simple random sampling methods were used to sample the population. In addition to that, the data were collected with the aid of questionnaire and interview guide, documentation and field visit as they were the research instruments of the present study and they were presented means of tables, figures and charts; The findings were analyzed by using multiple regression analysis.*
Results: *Findings revealed that Musha Mines is a major producer of Tin, Tungsten, and Tantalum ores and is facing health and safety issues due to its mining activities. These activities generate local income, business opportunities, and family investment but also cause lung illnesses, biodiversity loss, water pollution, health issues, land productivity decline, and tree felling. Illiterate miners engage in antisocial behaviors due to excessive alcohol consumption, leading to increased crimes and prostitution. The study reveals that the mining practices at the Musha site account for 75.3% of the variance in socioeconomic and environmental impacts, indicating a strong relationship between the variables. The high R Square value and Adjusted R Square value further support this strong correlation.*
Conclusion*: The government should offer technical assistance to local mine stakeholders, regulate waste, develop less chemical-intensive equipment, establish independent monitoring teams, combat illegal mining, and support other industries for environmental, social, and economic management of natural resources Finally, the government should control whether mining companies have future plans for mining closure and rehabilitation.*

Keywords: *Mining Practices, Socio-Economic, Environment, Eastern Province, Musha Mines, Rwanda*

i. Introduction

Globally, mining activities have positive and negative impacts on environment. These include: the production of goods, services, and infrastructure that raise the standard of living for people on a daily basis depends on mining. We are

privileged to benefit from the numerous advantages that mining metals helps provide as a developed society. These advantages include affordable, dependable power as well as the resources required to construct social infrastructure. Sociologically speaking, mining often creates jobs locally and boosts local and regional economies. (Pritchard et al, 2014). On the other hand, Climate change, pollution, soil erosion, deforestation and habitat degradation, conflicts between humans and wildlife, and biodiversity loss are a few examples are negative impacts of mining practices on the environment. In addition, mining may increase pollution, dust, and noise levels as well as contaminate nearby wetlands and streams. (ibid)

In a general sense, Mining may present significant economic opportunities that promote sustainable growth in poor nations all around the world (Alkire et al. 2015). Mining is still controversial, though, since it has been demonstrated that truly sustainable development depends on much more than just economic opportunities. A number of significant environmental, social, and economic issues have been brought about by poorly planned and executed mining operations (Ross, 2001). This has caused some to doubt mining's ability to provide long-term benefits. These days, a lot more consideration is given to the technological viability, economic potential, environmental impact, and social equality of mining development (Essacu 2018).

According to World Bank, (2013), Africa Mining Vision 2050, which encourages African nations to harness the potential of mining to improve rural livelihoods and spark entrepreneurship, as well as to promote local and integrated national development as well as regional cooperation, may have acknowledged the significant role that mining activities play in promoting trade and subsidiary business developments around the mining industry (SAIIA, 2012).

In Africa, about thirty percent of the world's mineral resources are found in Africa. Massive deposits of coal, iron ore, aluminum, uranium, and platinum-group metals are also found there, along with the largest known reserves of a variety of strategically important minerals, such as phosphate, gold, diamonds, chromite, cobalt, manganese, and vanadium (Taylor et al. 2009). Going about business as usual has the risk of accelerating the loss of Africa's forests and other natural areas, which would lead to a decline in biodiversity. This is because of the rapid rise of mining. Promising initiatives that could lessen the risks associated with mining while boosting chances for sustainable development include the Extractive Industries Transparency Initiative (Weng et al. 2013) and several bilateral mining-for-development projects (AusAID 2011).

Although many of the objectives and issues of the Africa Mining Vision are addressed by the mining laws and policies of the five East African nations that were the subject of the study, the nations have not yet made any attempt to specifically align their mining regimes with that Vision, and most of the time, any references to the Africa Mining Vision in these regimes are at best incidental. Different mineral rights are granted under the legislation of different nations. Although some are more democratic than others, all five nations have worked to improve accountability and openness in the management of their mining regimes. For instance, Kenya is now distributing the authority of its mining commissioner, who must now get approval from the national Mineral Rights Board before using a large number of their powers. In a similar vein, the Mining Advisory Board was established by the United Republic of Tanzania. (AMDC, 2017)

In Rwanda, mining is mostly done on a modest scale and focuses on basic metals like tungsten (wolframite), tantalum (coltan), and tin (cassiterite). Small quantities of limestone, peat, and gold are also produced in Rwanda. Small-scale domestic business owners and mining cooperatives make up the bulk of activities. However, other from the production of cement, bricks, and tiles, the nation does not process many minerals. However, Rwanda contributes significantly to the worldwide production of minerals like tungsten, tin, and tantalum; in 2012, for instance, it produced almost 12% of the world's tantalum. (Ibid)

In Rwanda, mining operations frequently have a big environmental impact. For example, the extraction and quarrying of sand already has a considerable negative impact on the environment due to resource depletion, energy use, waste production, and air pollution emissions. The hazards that mining poses to human life and health include population displacement, altered land usage, and noise and dust pollution. (REMA Report, 2021). Actually, the extraction of ores, which uses a lot of water, is one of the primary causes of stream water pollution in Rwanda. For example, silt and clay particles carried over long distances by the waters draining the mining sites of Rutongo and Gatumba have contaminated the rivers Nyabarongo and Nyabugogo.

This high mineral content contributes to the rivers' characteristic dark color that characterizes Rwandan waterways. Large volumes of rock and soil are discovered in nature, which are massive rejects from mining and quarrying. The mineral waste is carried down valleys by rainwater erosion, where streams are loaded with it and covered with slot that may be dangerous to wildlife (Ibid).

On the other hand, about 50,000 people, or 16% of the total, are working in the mining industry; 14,000 of them work in quarries, and 773 sites are being explored or exploited. 259 firms run 269 of the 369 active mining sites, while 36 companies deal with the processing and export of minerals. In 2015, a new draft of the mining and minerals policy was created. The environment, society, growth, employment, and productivity are the main points of emphasis. (Ibid)

According to this report, to achieve the objectives set forth by the EDPRS, the mining industry must take several steps, such as increasing the capacity for domestic mineral extraction and processing, creating a sub-regional mineral processing hub, and improving the quality of locally produced construction materials. In order to lessen the import of building

materials, these could encourage the private sector's involvement in exploration, mining, and processing as well as the value-adding of quarry products.

Musha Mines Tin and Tantalum mine with a mining concession of 3,894 ha and total concession of 6,094 ha. This mining site, is under Trinity Metals company. Primary site located within the Musha tunnel, with a number of satellite small-scale sites nearby. On the other hand, The Ntunga mining area holds significant tin, tantalum and lithium potential (2,200 ha), which forms part of the Musha concession. In 2023, the company employs 1,400 people, 98% of which are from nearby communities (Trinity Metals, 2023). The main objective of this study was to assess how how mining operations in Eastern Province, in the areas around MUSHA mines, are affecting the ecosystem. It was guided by the following specific objectives:

i. To assess the mining practices around Musha mines
ii. To assess the socio-economic and environmental impacts of mining practices.
iii. To evaluate the relationship between mining practices in MUSHA mines and the socio-economic and environmental impacts.

ii. Theoretical Review

1. Mine lifecycle Planning and Enduring Value for Remote Communities

The proponents of the theory are Stuart Robertson and Boyd Blackwell and it has been issued in 2014. This theory is about the literature on the socioeconomic effects of mining, mine closure, enduring value, and mine lifecycle planning. A community must "normalize" rather than becoming a "closed" town, have government backing and investment, and take advantage of economic diversification options in order to benefit long-term from mining. These circumstances must be taken into account in two ways: 1) during the design stages of the mine and town, and 2) during the mine's lifetime through continuous monitoring and community involvement. Mine lifecycle planning: is defined as the planning process involved in the development of a potential mineral extraction operation, where its lifecycle is planned from at least commencement of mining and ideally from the exploration stage. This cycle has four stages: exploration, project development, operations, and mine closure.

If the exploration stage confirms there is a mineral deposit that can be mined economically, the project development stage begins. The exploration and project development stages often overlap.

The project development stage**:** comprises: environmental and social impact assessments; development of sustainability and community programmes; and regulatory and government approvals. Consideration should be given to the idea of creating long-term benefits from mining for the impacted community during the project planning phase. For instance, Franks recommends that a mine plan should strive for results that improve the area around the mining project's post-resource futures.

Pre-feasibility studies for mines are now advised to include planning for mine closure**.** A sustainable community centered on the mine should be considered at the pre-feasibility stage, as should the necessity of a Fly-In-Fly-Out (FIFO) workforce. Moreover, we contend that closure planning ought to be done throughout the mine's lifespan.

By creating workable economic alternatives, converting mined land to cash crop land, and scheduling subsequent mining operations, planning for mine closure can benefit both the mining business and the local community or region. Reducing the scope and expense of final remediation, lessening the possibility of future stringent regulations, easing friction and conflict with nearby populations, and enhancing the company's reputation are some of the advantages for mining firms. Unplanned mine closures or the abrupt switch to a care and maintenance mode can be detrimental to the surrounding community, particularly the towns whose economies depend. (International Journal of Rural Law and Policy, Special edition 1,2014). This theory is relevant to our study because it shows how mining operations should be planned to reduce the impacts of mining on environment even on livelihood of the surrounding community. Importantly mining can have negative as well as positive impacts on dependent communities, both of which need to be considered in planning processes.

2. Management of Mineral Resources, Creating Value in the Mining Business

This theory was written by Juan P. Camus ″ and it has been published in 2002.This theory is about the management of mineral resources that creates value in the mining business. The process of creating plans and overseeing their execution is known as management. These plans pertain to a strategy that specifies how a mineral resource is to be exploited. The organizational context in which the process takes place and the range of methodologies available for the analysis are its two key components. According to the theory, Mine planning has traditionally been thought of as an engineering job that primarily deals with the layout of a mine and the practicalities of its expansion. The data was provided by the geological function, any valuable components were removed by the mineral processing function, the contracts were written by the sales function, and the funding was secured by the finance function.

Numerous academic fields, including business administration, organization, economics, psychology, sociology, and political science, have benefited from the contributions of this theory. No matter which perspective is chosen or the range

of perspectives from which this field is examined, management is always understood to be a process that involves coordinating all available resources to carry out long- and short-term planning as well as planning. Furthermore, management involves organizing, inspiring, and guiding others. Finally, but just as importantly, it involves managing every organizational process to achieve the company's declared objectives.

Effectively, managing a mining company's human resources is crucial, but so is effectively managing the company's mineral resources in order to ensure its success. Koontz's (1961) theories regarding the integration of management with other disciplines are crucial in this regard. According to him, other disciplines should be seen as significant foundations of the subject, and management should be viewed as a distinct discipline.

To conclude one can, realize that this theory is related to this study in the way that it emphasizes on the importance of management in mining practices. So, before any mining practice, mining companies should plan, evaluate by specifying how a mineral resource will be exploited as well as the range of methodologies available that will be used in its exploitation; the impacts of mining practices must be analyzed in the management theory.

3. Resource Curse Theory (Paradox of Plenty)

Authors: Andrew Warner & Jeffrey Sachs (1995), Richard Auty (1993). According to this idea, nations with abundant natural resources including mineral frequently have slower rates of economic growth, weakened democracies, and subpar development results as a result of economic mismanagement, corruption, and violence. If mining is not handled properly, it may exacerbate these adverse consequences.

4. Sustainable Development Theory

World Commission on Environment and Development (Brundtland Report, 1987) is the author or authors. The goal of sustainable development is to satisfy current demands without endangering the capacity of future generations. The effects of mining are investigated under the headings of economic equality, social displacement, and environmental destruction. The ideology promotes striking a balance between social justice, environmental preservation, and economic gains.

5.Triple Bottom Line (TBL) Framework

John Ellington is the author or authors (1994). TBL stresses that businesses, particularly mining enterprises, should prioritize the three Ps: profit (economic), planet (environmental), and people (social). This paradigm is used to evaluate mining's wider effects, which go beyond financial gains.

iii. Conceptual Framework

The conceptual framework illustrates how mining affects socioeconomics and the environment. This is predicated on an analysis of the body of existing literature. On the other hand, mining techniques might be surface mining or underground (deep shaft mining). There are effects on the environment and human health with all of these strategies. The researcher takes into account both independent and dependent factors for this study, as shown in Figure 1. Mining methods were the study's independent variables, while environmental wellbeing was its dependent variables.

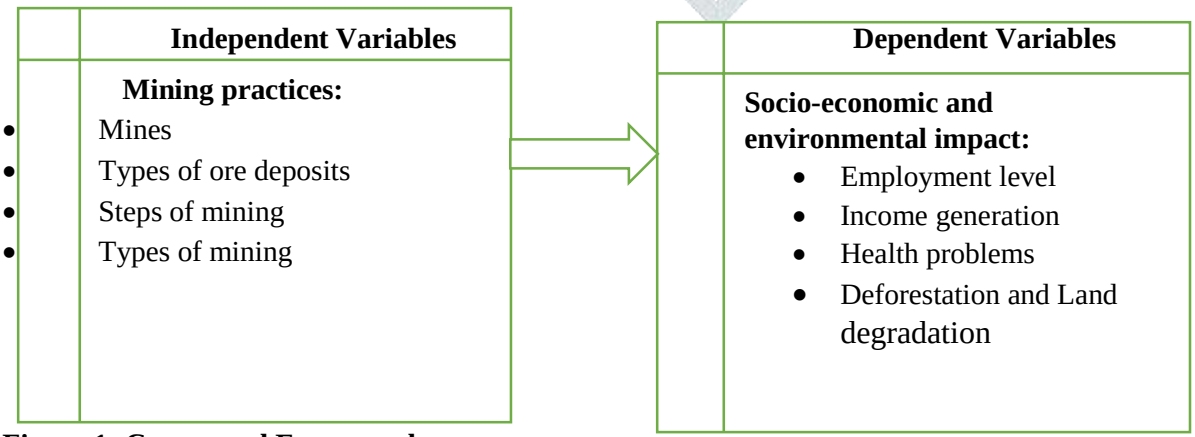

Figure 1: Conceptual Framework

Definition of Key Terms

1. Mining Practices

Allude to the strategies, procedures, and methods employed to find, extract, and refine mineral resources from the ground. These include methods for managing the environment, processing minerals, and mining both underground and on the surface. Environmental, technical, and regulatory advancements had a significant impact on mining methods in 2023, especially because of the growing demand for vital minerals required for green technologies like renewable energy systems and electric automobiles.

According to the International Energy Agency (2023), In order to lower carbon emissions, enhance worker safety, and guarantee ethical material procurement, mining processes have progressively embraced sustainable and responsible techniques. Stricter ESG (Environmental, Social, and Governance) regulations, automation, and digital transformation have emerged as crucial components of contemporary mining operations. (IEA, 2023).

2.Environment

C.C. Park (1980) has defined the 'environment' as "the sum total of conditions which surrounds a man at a given point. According Douglas and Holland (1947), the term environment is used to describe, in the aggregate, all the external forces, influences and conditions, which affect the life, nature, behaviour and the growth, development and maturity of living organisms. Environment Management Plan: An Environmental Management Plan (EMP) is a set of guidelines intended to help projects meet their environmental protection and mitigation standards, which are usually necessary in order to obtain project permits and approvals. (Keystone Environmental, 2022).
According to Keystone Environmental (2022), the environmental management plan (EMP) incorporates methods intended to safeguard, rehabilitate, and return the environment to its productive state before, during, and after exploration, making it a tool that can guarantee sustainable mineral exploration. It's a risk management plan with a rational structure, mitigation strategies, monitoring programs, and management controls. The creation of processes for carrying out project mitigation measures and needs monitoring is the aim of an environmental management plan (EMP). It is recognized as a risk strategy that uses management control techniques and a logical framework to significantly lessen possible environmental effects. The community is reassured by the EMP that the project's environmental management is sufficient. along with outlining the obligations and functions of each project participant.

3. Socio-Economic Impacts

The wide variety of consequences that mining operations have on the financial stability and social cohesion of nearby towns and regions are referred to as the socio-economic repercussions of mining practices. Both good (such the creation of jobs, improved infrastructure, and higher government revenues) and negative (like community relocation, rising inequality, health concerns, and disruption of traditional lifestyles) effects are possible. The advantages of mining are frequently not shared equally, which can cause societal unrest and a sustained reliance on one economic sector. Furthermore, these consequences can be exacerbated by poor environmental management and insufficient legislation, especially in developing nations. (Mensah, J. V et al, 2023)

4. Environmental Impacts

The several ways that mining operations effect the environment are referred to as the environmental implications of mining practices. These include:(1) Degradation of the land: Mining frequently causes soil erosion, topsoil removal, and deforestation, which results in the loss of fertile land. (2) Water pollution: Mining chemicals, such as mercury and cyanide, can contaminate adjacent water bodies, harming aquatic life and supplies of drinking water. (3) Air pollution: Emissions and dust from mining activities deteriorate the quality of the air and cause respiratory issues. (4) Loss of biodiversity: Mining can endanger plant and animal species and ruin their habitats. (5) Climate change: Greenhouse gases released by mining operations contribute to global warming, (Badera, J et al ,2023).

iv. Research Methodology

1. Research Design

A research design, according to Sumbl (2023), is a framework of strategies and tactics used by a researcher to integrate different research components in a relatively logical way in order to effectively address the research topic. It offers guidance on "how" to carry out research with a specific technique. Research design can be used to evaluate the list of research questions that each researcher has. Research design can be used to create a sketch of the proper way to do research.
Research design can be broadly classified into quantitative and qualitative research design:
Qualitative Research approach: In order to comprehend ideas, viewpoints, or experiences, qualitative research entails gathering and evaluating non-numerical data (such as text, audio, or video). It can be applied to provide fresh research

ideas or to obtain in-depth understanding of an issue. The opposite of quantitative research, which gathers and examines numerical data for statistical analysis, is qualitative research (P. Bhandari, 2020).

Quantitative Research approach: When a researcher needs to draw statistical inferences in order to gather useful information, quantitative research is used. Making critical business decisions is made easier with the help of numbers. Any corporation that wants to expand must adopt quantitative research design because any conclusions based only on data and analysis will only benefit the company. (Sumbl, 2023).

In the current study, both general research strategies were used, this is to mean that I used mixed research approach (qualitative and quantitative research approaches) and all gathered data were displayed as numerical data (quantitative research design). This study looked at the environmental effects of mining in Rwanda, particularly as it relates to the Ntunga-Musha mines. The results of a survey regarding these effects were displayed statistically. In order to describe the data collected from targeted respondents which included some miners, locals, and representatives of Trinity Metals that operate at this site the study combined a quantitative and qualitative research approach with a survey design. An interview guide was utilized with those respondents (qualitative design). Following that, the descriptive analytical method was used to interpret the data.

2.Population And Sample Size of the Study

The entire population of the study who are supposed to provide information data related to the objectives of the study is based on 2571 miners of Trinity Metals, 25 leaders of Trinity metals and 35 habitants of Kagarama and Ntunga cells located near mines. The total population is 2631people. Before identifying the respondents to this research, it is necessary to indicate how the sample size is determined. The sample size of the study was calculated using the following formula invented by YAMEN Taro in 1967; this formula was used in order to calculate the sample sizes and it is shown below:

$n= \frac{N}{1+N(e)^2}$

Where n is the sample size, N is the population size, and e is the marginal error of 5% through level of confidence of 95%. Thus, this formula is applied to the above sample.

N= 3631 , e= 5% = 0.05 .Then, $n=\frac{2631}{1+2631(0.05)^2} = \frac{2631}{6.5775} \simeq 400$ respondents

So, the sample size of this study is 400 respondents.

The target population of this study is composed by some trinity metals miners, some trinity metals leaders and some local habitants**.** To calculate the size**,** the rule of three formulae for stratified sampling is used (Cohen, 2003);

Proportionate Stratified Sampling Formula

$ni= \left(\frac{Ni}{N}\right) \times n$

Where ni= sample size for stratum i

Ni= population size of stratum i

N= Total population size

n= Total Sample size

stratum A (miners of Trinity Metals) =2571

Stratum B (Trinity Metals leaders) =25

Stratum C (Some population of Kagarama) =15

Stratum D (some population of Ntunga Cell) =20

Table 1: Target Population and Sample Size

Categories Of Staff	Population	Calculations	Sample Size	Sampling method
1. Miners of Trinity metals	2571	$a= 400\times \left(\frac{2571}{2631}\right)$	391	Randomly
2.Trinity metals leaders	25	$a= 400 \times \left(\frac{25}{2631}\right)$	4	Randomly

3.Some population of Kagarama	15	a= $400 \times \left(\frac{15}{2631}\right)$	2 Purposively taken
4.Some population of Ntunga cell	20	a=$400\times \left(\frac{20}{2631}\right)$	3 Purposively taken
Total	**2631**		**400**

Source: Primary data, March 2024

3. Data Collection Techniques

This section is aiming to show the research collection techniques of the study including questionnaire, interview guide and documentation research techniques as follows:

Questionnaire / Survey

To collect the data for the first objective, concern the impacts of mining practices on environment, the questionnaire helped the researcher as main means of communication between him and respondents. Questionnaire included the series of questions about issues that are expected of the respondents' information, where these types of questions were distributed by the researcher among respondents in order to collect the written and quantitative data (information). In addition, they were administered to miners of Ntunga-Musha mines who were taken randomly basing on the number of respondents as it has been calculated. Not only miners but also some habitants from nearby communities.

Interview Guide

Krlinger (2017) defines an interview as a dialogue in which the researchers attempt to elicit information from the participants. By asking qualitative questions that are relevant to the study's goals, the researcher was able to directly obtain information from respondents. As a result, this method enabled the researcher to verbally get information from a chosen group of participants. Interviews with four Trinity Metals executives, two Kagarama residents, and three Ntunga cell residents were conducted in order to collect qualitative data about the negative impacts of mining operations in Musha. These responders were chosen since they are the ones that reside close to the Musha Mines mining village and their information is reliable.

Documentary Review

A qualitative research technique called documentary review, often referred to as document analysis, is methodically going over and analyzing preexisting materials in order to glean important information pertinent to the study's goals or concerns. Reports, newspapers, policy documents, meeting minutes, historical records, websites, and more can all be considered textual, visual, or digital documents. (Bowen, 2021) This study utilized the archives from Trinity metals bureau. This instrument, was a key for having the population and respondents classified into miners and leaders of Trinity Metals company.

Field Visit

The researcher was able to evaluate the site area as well as the plant, animal, and neighborhood life by conducting field trips to the mining project sites and the surrounding environment of the Musha mining village. In Musha, a photographic mine was captured. By visiting the study location, the researcher was able to learn more about the contemporary environment. This method was crucial for using images to teach about the many types of mines in Musha mining.

4. Methods and Tools of Data Analysis

A collection of mathematical techniques derived from the gathering and examination of actual data is known as statistics analysis. The research results can be measured and quantified thanks to the statistical, analytical, descriptive, and synthetic research methods for data analysis. As a result, these research analyses will make it easier to number and quantify the research results and present the data by using in tables and charts as research tools. The data was presented and analyzed based on three research objectives by comparing them to the findings of this study. Furthermore, multiple regression analysis was used to analyse the data statistically, in this regard ANOVA was used in order to establish relationship between variables composed by Mining practices (Independent variable) and Socio-economic and environmental impacts (Dependent variable); these calculations were found using SPSS.

v. Research Findings and Discussion

1. Demographic Profile of Respondents

400 individuals made up the sample of respondents for this study and the researcher asked them to comment on various elements of how mining affects the environment in Rwanda, with a particular focus on the Ntunga-Musha Mines in the Rwamagana district. The respondents included some locals living close to the mines, leaders, and miners employed by Trinity Metals Company. The respondents' age, gender, marital status, and educational attainment are all included in their demographic profile as follows:

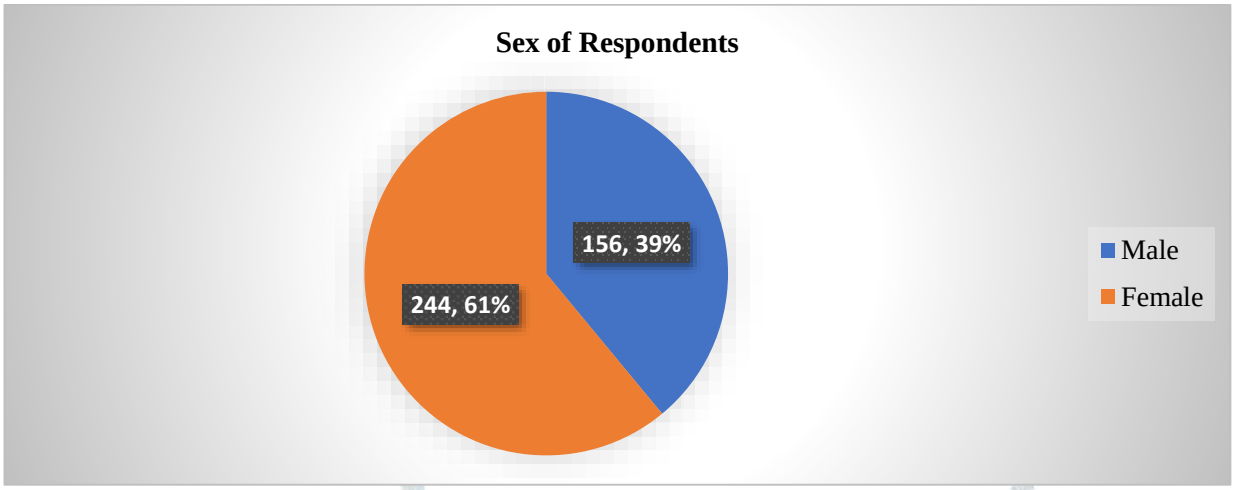

Figure 2: Sex of Respondents

The respondents are composed 156 males (39%) and 169 females (61%) distributed in miners, some inhabitants near mines and some of Trinity Metals leaders.

2. Assessing the Mining Practices

In this section, the research findings are outlined according to the first objective that directed the study, which was to assess the mining practices around Musha mines and each indicator of independent variable has been considered.

2.1 Mines

Safety measures must be included in both surface and underground mining. 400 respondents were given a questionnaire that focused solely on the adoption of health and safety measures techniques in Musha mines, and four factors were taken into consideration in order to gather the data: dangers unique to mines, emergency response plans, and the use of personal protective equipment (PPE), in contrast to evacuation and communication protocols; responses were given using five points Likert scale ranging from strongly agree to strongly disagree where 1 represents disagree, 2 strongly disagree, 3 neutral , 4 agree and 5 strongly agree. Table 4.4 presented such findings.

Table 3: Assessing Health and Safety Measures Strategies in Mines of Musha

Indicators	Mean	St.Dev
1.Dangers unique to mines are available	3.91	0.42
2.Emergency response plans are available	4.18	0.41
3.Personal protective Equipments are used most of the time.	4.26	0.88
4.Evacuation and communication protocols are available in Musha mines.	4.30	0.72
overall mean / St.dev	**4.16**	**0.60**

Interpretation: An average rating of 1-2 on a 5-point Likert scale often denotes low agreement, 3 denotes neutral or moderate agreement, and 4-5 denotes strong agreement in research. (M. Anthony and others, 2021). The analysis of table 4.4 indicates that the high Likert scale of points mean of 4.30 for statement 4 indicates that communication and evacuation

methods are available in Musha mines. Furthermore, the aggregate mean of 4.16 showed that respondents agreed with all four claims. It is evident that the proprietors of Musha Mines have implemented safety and health precautions to safeguard their employees, but given the ongoing health and safety issues at Musha Mines, these precautions are insufficient.
Nonetheless, standard deviation might be investigated in the way outlined below: When the standard deviation was low, there was a high level of agreement among the respondents. Given the wide range of replies, a large SD denotes disagreement. Last but not least, table 4.4 above shows how every response disputes the claim that Musha mines implement and enforce safety and health precautions. Musha has a high availability of emergency reaction plans, as demonstrated by the table's tiny St.dev of 0.41.
Hermanus (2021) outlined the plan to tackle mine-related illnesses including silicosis by enhancing occupational health surveillance and personal protective equipment (PPE). In order to implement this plan and prevent long-term sickness among mine workers, health monitoring and early detection are essential. The Trinity Metals corporation does not keep an eye on the health of its employees near the Musha mines.

2.3 Types of ore deposits

To collect the data, the interview guide has been used. The interview was administered to four Trinity Metals leaders; in order to be informed on the types of ore deposits they extracted in their mines. According to Trinity Metals leader's information, Musha mines produce 3 Ts to mean Tin, Tungsten and Tantalum. Apart from those minerals, Musha mines also produce Coltan extracted from Duha in Musha sector. Hence, the data collected are qualitative ones.
Furthermore, in order to collect the recent quantity of minerals extracted from Musha mines, documentary review has been used by considering Official Rwandan Mining Authority Reports and Academic Source on Rwanda's Mining Sector. The following are the findings:
In 2023, there were around 1,200 metric tons of cassiterite (tin ore) used to manufacture alloys, plating and soldering of electronics. On the side of Coltan (Columbite-Tantalite), 500 metric tons are anticipated in 2023.This ore, is used to supply Tantalum for electronic capacitors. Finally, in 2023 there were around 800 metric tons of Wolframite (Tungsten ore) and it is used for military applications, strong metals and filaments (RMB et al, 2024 & Munyaneza et al, 2023).

2.4 Steps of Mining

In this section, Mineral processing, Mine development, extraction/ mining operations and mine closure and rehabilitation have been considered as mining steps for ensuring the ways proprietors of Musha mines applied the steps of mining. During the administration of a questionnaire, four hundred respondents were shown the indication for each stage. Table 4. presented the findings.

Table 4: Application of Mining Steps in Musha Mines

Indicators	Mean	St.dev
1.Chemicals are used in mineral processing.	3.69	0.88
2.In mine development, local people are employed.	4.38	0.59
3.Fatality and incident rates is high because of mineral extraction.	2.63	0.88
4. Trinity Metals company has long term plan in the future mining closure and rehabilitation.	3.74	0.56
Overall mean / St.dev.	**3.61**	**0.72**

Table 4 was analyzed to determine that chemicals are used moderately in mineral processing (the corresponding mean is 3.69, indicating a moderate or neutral response); mine development with the local employment indicator (the mean is 4.38, indicating a high agreement on this statement); and mineral extraction does not result in high rates of incidents and fatalities (the mean is 2.63, indicating a high disagreement). The mean, then, is 3.74 based on Trinity Metals Mining Company's long-term plan for the mining phases, suggesting that individuals are unaware of the company's strategy for mine closure and rehabilitation. Given that the total mean is 3.61, the mining stages are often applied lightly.

Mining companies employ chemicals to separate valuable minerals from ore as part of the mineral processing steps, but they should minimize the negative effects of these processes by switching to more ecologically friendly methods like magnetic separation, making the best use of currently available chemicals, and creating novel bioprocessing techniques

(Kumar et al., 2022). Nyandwi and Rurangwa (2022) said that in order to grow mines, the community should be employed and mining infrastructure, such as roads, should be built. However, smart mining and automation should be applied to lower the death and incident rates in mineral extraction (Zhang et al, 2022). Lastly, as part of the mining closure and rehabilitation process, mining corporations should prepare for environmental recovery, monitoring, and land usage (Mhlongo & Amponsah-Dacosta, 2022).

2.5 Types of Mining

The interview guide has been utilized to get the data. Trinity Metals' secretary, who oversees the organization's archives, was the interviewee. The topic of the conversation was the kinds of mining techniques employed in Musha Mines. Chapter 2 describes the surface and underground mining methods used in Musha mines, based on information supplied by the secretary and archives of Trinity Metals. The following are their images

Figure 3: Surface Mining Image

Source: Online Picture

Figure 3: Underground Image

source: Posted by Trinity Metals Company on Google

2.6 Socio-Economic and Environmental Impacts of Mining Practices

The second objective was to assess the socio-economic and environmental impacts of mining practices. The socio-economic and environmental impacts are classified into positive and negative impacts and they are presented basing on the following indicators: employment level, income generation, health problems and deforestation and land degradation.

2.7 Employment Level and Mining Practices

The supply of goods and services for mining activities creates both direct and indirect jobs in mining areas. Jobs created by direct and indirect employee spending and rising consumption are known as "induced jobs." (Professor William Baah, 2018). The results were compiled in table 5 below:

Table 5: Assessment of Job creation by Musha mines

Statements	Mean	St. dev
1. Mining improved employment rate.	4.83	0.43
2.Mining increased consumption at your markets and shops.	4.50	0.67
3.Mining increased the benefits from agriculture.	4.15	0.75
4.Mining increased services availability	3.72	0.54
Overall mean / St.dev	**4.3**	**0.59**

Table 5 showed that employment rates in Musha rose as a result of mining activities, with some locals employed as miners for Trinity Metals Ltd. The related mean for this statement is 4.50; the means for the other assertions are 4.15 and 3.72, respectively. Mining activities also enhanced consumption at markets and stores by bringing in more consumers, which is supported by the mean of 4.83. In the end, it became clear that people saw mining's benefits for service availability more indirectly than directly. Additionally, one of the benefits of mining operations in the Musha sector and even elsewhere in Rwanda is the degree of employment.

2.8 Income Generated by Mining Practices

Table 6: Income generation with mining practices in Musha sector

Indicators	Mean	St.dev.
1.Mining increased demand for local services and goods.	4.06	0.74
2.Mining increased business opportunities in your region.	4.06	0.76
3.Mining enables families to invest in farming, trade or education.	4.83	0.38
4.Mining changes in poverty rates within mining communities.	4.73	0.57
Overall Mean / St.dev.	**4.42**	**0.61**

Mining activities in Musha raised income levels because of the increased demand for local goods and services, the growth of business opportunities in the area, the investment made by families in farming, trade, or education as a result of their increased income, and the changes in poverty rates within mining communities. Furthermore, table 6 statistically demonstrated that mining operations generated revenue in the Musha sector, which is explained by an aggregate response mean of 4.42, which indicated substantial agreement in responses on the point Likert scale. All of the data presented in Tables 5 to 6 discussed the positive socioeconomic effects of mining practices in the Musha sector. According to Minaei M. (2014), in order to support this information, the impacts include the following: the mining industry creates a large number of jobs and income, which increases longevity and welfare; mining activities also produce technical and generic skills in the area, which enhances the community and culture surrounding the mine region; and mining operations provide food and public services.

2.9 Health Problems Caused by Mining Practices

Mining practices do not have only positive impacts but they have also negative ones; that is why the researcher collected information related to health problems caused mining practices to mining or non-mining communities. The table 7 presented such information by using the questionnaire research tool.

Table 7: Assessment of health problems caused by mining practices

Indicators	Mean	St.dev.
1.Mining caused injuries, joint problems or fatalities.	4.33	0.82
2.Mining caused respiratory diseases (eg. Silicosis).	4.12	0.80
3.Mining activity caused the loss of biodiversity like plant cover.	3.40	0.66
4.Mining activity caused Contaminated-Related water illness (eg. Diarrhea).	3.78	0.53
Overall mean/ St.dev.	**3.90**	**0.70**

According to an analysis of Table 7, most respondents agreed with every assertion pointing to health issues brought on by mining operations. The fact that the overall mean on the five-point Likert scale is 0.90 closer to agree (4), indicating generally positive but not overwhelmingly so, supports this knowledge. There is modest response variability, as indicated by the overall St.dev. of 0.70. This suggests that there was some variety, but not much, even if the average response tended toward agreement. Accordingly, mining activities in Musha resulted in lung illnesses like silicosis, a loss of biodiversity like plant cover, polluted water illnesses, and health issues like injuries, joint issues, or fatalities (deaths).

2.10 Mining Practices and Deforestation and Land Degradation

Mining operations harm the environment in a number of ways, including by destroying habitats and biodiversity, degrading soil, polluting water and air, and contributing to climate change. The issues in this area are land degradation and deforestation. Additionally, the information gathered was displayed in table 8 below:

Table 8: Deforestation And Land Degradation in Musha Sector

Indicators	Mean	St.dev.
1.Mining activities caused loss land of productivity.	4.33	0.82
2.Mining practices caused water overuse.	3.79	0.67
3. Mining activities caused landscape Alteration.	4.16	0.69
4.Mining activities caused rate of tree felling or lagging activity.	4.12	0.80
Overall mean/ St.dev.	**4.1**	**0.74**

Table 8 revealed that mining activities in the Musha sector, particularly in mining communities, resulted in decreased land productivity, altered landscapes due to the potential for abandoned mines to leave unsightly and dangerous scars on the land, and increased rates of tree felling or lagging activity. The mean for water usage is 3.75, indicating that people are not fully aware that the mining activities in the Musha sector use a lot of water, contributing to the region's water shortage. Additionally, there was substantial agreement on those claims, which may be explained by the overall mean of 4.1. Other indices of land degradation and deforestation have also been proven to have means ranging from 4.

3. Findings from the Interview Guide About the Impacts of Mining Practices

Since they are the ones who reside in mining villages, the researcher interviewed five residents of Kagarama and Ntunga cells and four Trinity Metals leaders in order to evaluate the data gathered via the questionnaire. The socioeconomic and environmental effects of local mining operations served as the basis for the interview. According to the information provided by four Trinity Metals leaders, their mining activities sometimes caused the loss lives, because in 2024, 15 miners perished due to the collapse of mines in Musha. In this line of thoughts, they continued by saying that Musha mines caused hand injuries, slip and fall because of bad structure of mines. Furthermore, before TRINITY METALS company operates at MUSHA mines, many local people died due to illegal mining they practiced; by now, negative impacts have been reduced.

The additional information from interview guide with five inhabitants in mining communities stated that, despite the positive effects of mining practices, there are drawbacks as well. For example, mining practices in Musha led to an increase in antisocial behaviors like prostitution, drinking, and crimes because illiterate miners received large sums of money and wasted them by drinking a lot of alcohol. These antisocial behaviors are still present in the area near mines, but they were more prevalent when illegal mining was practiced there. However, they are now declining as a result of Trinity Metals' legal mining operations.

4.Relationship Between Mining Practices and The Socio-Economic and Environmental Impacts.

The link between two dissertation variables is shown in this section. With the use of SPSS, or the Statistical Package for the Social Sciences, statistical analysis techniques such multiple regression analysis were used to gather the data.

Regression Analysis to Determine the Relationship Between Variables

Table 9: Model Summary

Model	R	R Square	Adjusted R Square	std. error of the estimate
1	0 .885[a]	0 .753	0 .760	650.22175

a. Predictors: (Constant), mining practices

Source: SPSS / April, 2025

Important metrics pertaining to the overall fit of the regression model are shown in the Model Summary table. The economic and environmental effects of mining activities are strongly positively correlated, as indicated by the R-value of 0.885. This indicates that changes in mining methods have a significant impact on the community's socioeconomic and environmental results. The R Square value of 0.783 suggests that 75.3% of the variance in socioeconomic and environmental impacts can be explained by the mining practices employed at the Musha mining site. This is a relatively high percentage, indicating that mining practices play a dominant role in shaping socioeconomic conditions in the area.

The Adjusted R Square value of 0.760 is also high and accounts for the number of variables included in the model, reinforcing the strong relationship between the variables. The Standard Error of the Estimate (650.22) reflects the average distance that data points fall from the regression line, giving a measure of the model's prediction accuracy. While this statistic is useful, its interpretation is more meaningful in context with other information from the model, such as the p-values and F-statistics.

The statistical technique of regression is used to estimate the relationship or associations between a dependent variable (y, or outcome variable) and one or more independent variables (x, or predicting variables). To help comprehend the variance in a dependent variable, regression analysis specifically analyzes the variation in independent variables with other confounding variables controlled. Where regression analysis meets machine learning is in the estimation and forecasting of the dependent variable's conditional expectation given the independent variables. Qinghua, Y. (2017). Furthermore, the researcher was able to quantitatively illustrate the relationship between mining practices in Musha and the effects of socioeconomic progress.

Table 10: Analysis of Variance (ANOVA[a])

Model		Sum of Squares	df	Mean square	F	sig.
1	**Regression**	4565332.222	1	4565332.222	10.798	046[b]
	Residual	1268364.978	3	422788.326		
Total		**5833697.200**	**4**			

a. Dependent Variable: socioeconomic and environmental impacts

b. Predictors: (Constant), mining practice

Source: SPSS / April, 2025

The ANOVA (Analysis of Variance) table assesses the overall significance of the regression model. The F-value of 10.798 tests whether the model is significantly better than using no predictors (i.e., a constant model). With a p-value of 0.046 (which is less than the significance level of 0.05), the result indicates that the regression model is statistically significant. This means that mining practices have a meaningful impact on socioeconomic and environmental status.

The Sum of Squares values show the variance in socioeconomic development explained by the model (regression sum of squares = 4,565,332.222) and the unexplained variance (residual sum of squares = 1,268,364.978). The Total Sum of Squares (5,833,697.200) represents the total variance in the dependent variable, and the proportion explained by the model (R Square) is 75.3%. Will K. (2024) stated that A statistical test called analysis of variance (ANOVA) is used to evaluate how the means of more than two groups differ from one another. Fundamentally, ANOVA enables you to compare arithmetic means across groups at the same time. You can determine whether the differences observed are due to random chance or if they reflect genuine, meaningful differences. In this study, mean responses concerning mining practices and socioeconomic and environmental impacts have been evaluated the way they differ among them.

5. Explanation and Interpretation of Results

The study sought to investigate the impact of mining practices on the socioeconomic and environmental impacts, a case of Musha mines in Eastern Province, Rwamagana district. Through prepared respondents it has been found that mining practices impacts negatively and positively. Musha Mines' owners have implemented safety measures to protect employees, but these are insufficient due to ongoing health and safety issues. Despite emergency response plans, these measures are insufficient. The mines extract Tin, Tungsten, and Tantalum ores, with tin being the most extracted. They use surface and underground mining, but no plans for closure or rehabilitation are known.

On the side of socioeconomic and environmental impacts, the findings revealed that Mining activities in Musha increased income levels due to increased demand for local goods and services, business opportunities, and family investment in farming, trade, and education. However, these activities also led to lung illnesses, loss of biodiversity, water pollution, and health issues. Land productivity decreased, landscapes were altered, and tree felling or lagging activity increased due to mining practices. Finally, it has been discovered that mining operations in Musha forced illiterate miners to engage in antisocial behaviors since they drank a lot of alcohol, which led to an increase in crimes and prostitution, among other things. They acted in this way because they believed they had a lot of money, which they squandered on various immoral endeavors. Mining activities also caused the loss of biodiversity, such as plant cover. Then, by using SPSS, the findings revealed that the mining practices at the Musha mining site account for 75.3% of the variance in socioeconomic and environmental impacts, indicating a strong relationship between the variables.

The R Square value of 0.783 and the Adjusted R Square value of 0.760 further support this strong relationship. On the other hand, all respondents confirmed that mining practices improved their conditions of living through providing to them jobs, for this reason, they developed economically. Mining practices have been the cause of improved infrastructure like good roads. Consequently, people around Musha mines confirmed that positive impacts of mining practices are better than negative ones. To analyze and interpret the results, the researcher compared them to other prior researches with the similar topics as they are explained in the paragraphs below:

The first study to compare to the present research project is "Effect of Mining Safety Risks on Human security in Rwanda, A Case of Mining Industry in Muhanga District; by Karemangingo Théodore". According to this report, many mineworkers have encountered risks related to mining safety while on the job. the lives of mineworkers; some suffer illnesses and injuries, while others pass away. The findings showed that 43 (62.3%) of all respondents had encountered risks related to mining safety while working, 52 (75.4%) of all respondents agreed that the most common risk for mining safety is minor injuries, and 58 (84.1%) of all respondents agreed that the company takes adequate precautions to protect mineworkers from mining-related risks. Similarly, this study is related to the present study because it concerned the negative impacts of mining activities on human lives and one can separate human lives from environment.

The second related study is entitled "The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District"; it has been written by Kitula, in 2024. This study examined the environmental and socio-economic impacts of mining operations in Tanzania, specifically in Geita District. It has been found the following environmental impacts of mining:

According to the Nyakabale village executive officer, since the inauguration of the Geita Gold Mine near the village, local people have reported approximately 52 cases of housing collapse resulting from mine-induced explosions. Mineral extraction involves the excavation of underground pits and the destruction of rocks using explosives, which has caused regional land degradation. The number of pits in the small-scale mining areas lies between 100 and 1000, at shaft depths ranging between 10 and 100 m; both agricultural and grazing lands have been destroyed.

On the other hand, mining activities in Tanzania caused social and cultural impacts such as labour accidents, and theft. The opening of the Geita Gold Mine has resulted in high influxes of migrants in search of jobs. This, in turn, has resulted in prostitution, increased incidences of banditry, changes to indigenous lifestyle, and increased competition among local residents for natural resources. On the side of positive impacts of mining activities, the findings were the following: There were notable differences between the advantages that the Geita Gold Mine Company
offered to mining and nonmining villages, especially in terms of better roads and water amenitywith nonmining commu nities appearing to be more neglected than their mining counterparts.The findings, which were supported by IDRC, sho wed that mining villages have benefited from a wide range of new services, including improved access to healthcare and education. These findings showed the way mining in Geita District impacts positively on the community nearby the area. So, the findings of this research are related to the present research.

vi. Conclusion

The study analyzed the socio-economic and environmental impacts of mining practices in the eastern province, particularly in Musha mines. It was found that mining degradation, exposure to toxic air, (air pollution), underground mining cause deaths, long-term land use, reduced water availability, and loss of biodiversity were significant issues to investigate about. In addition, it was found that proprietors of Musha mines do not have a future plan on mining closure and rehabilitation. With the aid of SPSS, it was found that mining practices have a strong relationship with socioeconomic and environmental status. According to those findings, mining practices are crucial to the population even though they have negative effects on them. However, the risks will be lower if they avoid being associated with illegal mining, and the mining industry should use cutting-edge technologies to lower the risks of fatalities because one can only prosper economically after one is alive.

vii. References

A. Bhardwaj (2022) Impact *of New & Emerging Technologies on Mining Industry" "Impact of New & Emerging Technologies on Mining Industry"*. MECON LIMITED (Govt. of India Enterprise): India

Adeyemi, O., et al. (2023). *Socio-economic impacts of mining in West Africa: Evidence from longitudinal surveys*. Resources Policy.

Albert K. Mensah1, Ishmail O. Mahiri, Obed Owusu, Okoree D. Mireku, Ishmael Wireko, Evans A. Kissi (2015): *Environmental Impacts of Mining: A Study of Mining Communities in Ghana.* Department of Geography, Kenyatta University, Nairobi, Keny

AMDC (2017*) Assessment of Mineral Regimes in the East African Community: Aligning Frameworks with the African Mining Vision.* Economic Commission for Africa: Addis Ababa –Ethiopia.

Badera, J., & Kocur-Bera, K. (2023). *Environmental impact of mining activities in Poland*: A review of current practices and challenges. Environmental Science and Pollution Research, 30, 12345–12360. https://doi.org/10.1007/s11356-023-26231-1
Balasubramanian (2016) *An overview of mining methods*. University of Mysore: Karnataka-India.
Bebbington, A., & O'Brien, P. (2023). *Resource management and community participation in mining regions*. Journal of Rural Studies, 40(3), 233–257.
Bowen, G. A. (2021). *Document analysis as a qualitative research method*. Qualitative Research Journal, 21(2), 121–134. https://doi.org/10.1108/QRJ-06-2020-0054
Brown, T., & Moyo, L. (2023). Mining sector employment and wage dynamics in Southern Africa. African Economic Review, 35(2), 115–133. https://doi.org/10.1234/aer.2023.0215
Chemonics International Inc. (2008). *Rwanda Environmental Threats and Opportunities Assessment 2008 Update. EPIQ IQC Contract No*. EPP-I-00-03-00014-00, Task Order 02. Biodiversity Analysis and Technical Support for USAID/Africa, USAID, Kigali
Chikezie, U., Okeke, M., & Adebayo, T. (2023). *Musculoskeletal disorders in artisanal gold miners in Nigeria.* Occupational Medicine International, *34*(1), 56–69.
Daniels, P., & Moyo, L. (2023). *Occupational hearing loss in Zimbabwean open-pit mines.* African Journal of Occupational Health, 29(3), 130–142.
Divya, S. (2023) *What is a Theoretical Framework? How to Write It (with Examples).*
Dushime, S. & Bimenyimana, A. (2022) *The Impacts of Mining Activities on Local Community Livelihood in Rwanda "Case of Rutongo Mining Site in Rulindo District"* (IJAEM): University of Lay Adventists of Kigali (UNILAK), Kigali-Rwanda
Ephrem, H.& Christophe, M**.** *(2020) Impact Analysis of Mining on Wetland Transformation in Rwanda*. East African Journal of Science and Technology: Kigali-Rwanda.
Hermanus, M. A. (2021). *Occupational health and safety in mining—status, new developments, and concerns.* Journal of the Southern African Institute of Mining and Metallurgy, 121(1), 1–10. https://doi.org/10.17159/2411-9717/1393/2021
Hilson, *G. (2023).* Mining and rural development: Reexamining socio-economic exchanges. Journal of Rural Studies, 40*(3), 233–257.*
Hilson, G. (2023). *Mining and rural development: Reexamining socio-economic exchanges*. Journal of Rural Studies, 40(3), 233–257.
International Energy Agency. (2023). *The role of critical minerals in clean energy transitions*. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions
International Tin Association. (2024). *Tin supply chain updates: Central Africa mining review*. Retrieved from https://www.internationaltin.org
Jean Pierre, B., Gilbert., Celse, G. & Théophile, N. (2021) *Spatial and Temporal Analysis of the Land Use and Land Cover Changes in Gatumba Mining Landscape, Rwanda.* UR-CST: Kigali-Rwanda.
Kamod K & Rathore (2020) *Environmental Impacts of Mining and Processing of Minerals*: a review. *Centre for Climate Change and Water Research, Suresh Gyan Vihar University, Jaipur
Kumar, A., Singh, R., & Tiwari, M. (2022). *Advances in sustainable mineral processing: A green chemistry approach*. Minerals Engineering, 181, 107615. https://doi.org/10.1016/j.mineng.2022.107615
Lee, H., Banda, C., & Mwamba, J. (2023). Corporate social responsibility and local income *generation in Zambia's mining regions.* Resources Policy, 80, 102456. https://doi.org/10.1016/j.resourpol.2023.102456
Lehmann, B., S. Halder, J. R. Munana, J. d. l. P. Ngizimana & M. Biryabarema (2013) The geochemical signature of rare-metal pegmatites in central Africa: magmatic rocks in the Gatumba tin–tantalum mining district, Rwanda. Geochemical Exploration, 11.
Lehmann, D., K. Brinkmann, R. V. Diogo & A. Buerkert (2017) Temporal and spatial changes of land use in rare metal mining areas of Rwanda. International Journal of Mining, Reclamation and Environment, 31, 519-529.
Lopez, H., & Diaz, E. (2023). *Water contamination and public health in mining regions*. *Journal of Environmental Medicine, 25*(4), 192–207.
M. Minaei Mob Taker M. Osanloo (2014) *Positive impacts of mining activities on environment.* Amirkabir University of technology (Tehran polytechnic): China-Beijing
Mensah, A. K., Antwi, E., & Obeng, E. (2021). *Surface mining and land use change in Ghana: Implications for agriculture and ecosystems.* Land Use Policy, 104, 105394. https://doi.org/10.1016/j.landusepol.2021.105394
Mensah, J. V., & Osei-Kojo, A. (2023). *Rethinking the socio-economic impacts of mining*: Evidence from sub-Saharan Africa. Resources Policy, 82, 103602. https://doi.org/10.1016/j.resourpol.2023.103602
Mhlongo, S. E., & Amponsah-Dacosta, F. (2022). *Mine closure planning and implementation: Best practices from sub-Saharan Africa*. Journal of Environmental Management, 318, 115559. https://doi.org/10.1016/j.jenvman.2022.115559
MINIRENA (2020) *Rwanda Mining Investment, Pitch Book*. Kigali-Rwanda
Ms. Tinki K. B (2022). Environmental *Geography*, Netaji Subhas Open University: Bengal - India.

Munyaneza, O., & Habimana, J. B. (2023). *Mineral production trends and economic impacts in Rwanda's mining sector*. African Journal of Natural Resource Economics, 8(2), 115–129. https://doi.org/10.1234/ajnre.v8i2.4567
Nkosi, T., & Banda, N. (2023). Psychological health in mining-affected communities. *Journal of Mental Health and Society, 22*(2), 98–113.
Nyandwi, E., & Rurangwa, J. P. (2022). *Community participation in mining development in Rwanda: Opportunities and limitations*. Journal of Sustainable Mining, *21(2), 45–54. https://doi.org/10.46873/2520-3999.21.2.4*
Owusu, D., Asare, K., & Tetteh, J. (2023*). Lead exposure and child health in gold mining communities in Ghana.* Pediatric Environmental Health Journal, 14(1), 21–35.
Oxford University Dictionary (2023) *Oxford Advanced Learners Dictionary*. Oxford University Press: UK
P. Bhandari. (2020**)** *What Is Qualitative Research? | Methods & Examples.* Scribbr: Amsterdam, the Netherlands.
Prince A. and Gabriel E. (2020) *Impact mitigation or ecological restoration? Examining the environmental sustainability practices of multinational mining companies.* Massey University: Auckland, New Zealand.
Prof. William Baah-B. (2018) *Job creation in the mining sector: evidence from Ghana.* University of Ghana: Ghana.
Rwanda Mines, Petroleum and Gas Board (RMB). (2020). *Annual report 2019–2020*. Kigali: RMB. Retrieved from https://www.rmb.gov.rw
Rwanda Mines, Petroleum and Gas Board. (2024). *Annual mining statistics report: 2023–2024*. Kigali: Government of Rwanda. Retrieved from https://www.rmb.gov.rw
RYUMUGABE Sam (2021) *Role of Small-Scale Miners towards Performance of Mining Projects in Rwanda. Case of Piran Rwanda ltd Mining Projects.* Global Scientific Journals: Kigali-Rwanda.
Santos, M., & Reyes, L. (2023). Assessing environmental degradation in mining zones of Latin America. Routledge International Handbooks: Latin America
Smith, J., & Zhang, Y. (2023). The macroeconomic impacts of mining in resource-rich countries. Journal of Global Economics, 47(3), 209–228. https://doi.org/10.1016/j.jge.2023.07.003
Sonter, L. J., Herrera, D., Barrett, D. J., Galford, G. L., Moran, C. J., & Soares-Filho, B. S. (2021). *Mining drives deforestation in the tropics. Nature Communications, 12*(1), 1384. https://doi.org/10.1038/s41467-021-21560-5
Stuart, R. & Boyd, B. (2014) *Mine Lifecycle Planning and Enduring Value for Remote Communities.* University of New England: Australia.
Sumbl A. K. (2023). *Research design*. Aligarh Muslim University: India
T. KAREMANGINGO (2020) *Effect of Mining Safety Risks on Human Security in Rwanda, A Case of Mining Industry in Muhanga District.* UR: Nyakinama.
Taylor, 1989, An Introduction to Ore Reserves. Page 5–12, Mining Industry International, vol. 990.
Trinity Metals (2023) *Creating Critical Excellence in Rwandan Mining*. Trinity Metals: Kigali- Rwanda.
United Nations Environment Programme. (2023*). Sustainability in the Extractives Sector: Global Assessment and Policy Recommendations.* Nairobi : UNEP. https://www.unep.org
Uwimana, A., & Nshimiyimana, A. (2021). *Environmental and health impacts of mining activities in Rwanda: A review.* Rwanda Journal of Engineering, Science, Technology and Environment, 4(2), 45–56. https://doi.org/10.4314/rjeste.v4i2.4
World Bank. (2023). *The Socioeconomic and Environmental Footprint of Mining:* A Global Review. Washington, DC: World Bank Group.
Wu, X., Li, Y., & Zhao, H. (2021). *Statistical analysis of coal mine accidents in China (2010–2020): Implications for safety improvement.* International Journal of Coal Geology, 245, *103763. https://doi.org/10.1016/j.coal.2021.103763*
Zhang, Q., Liu, Y., & Zhao, F. (2022). *Smart mining: Technologies and implications for efficient extraction*. International Journal of Mining Science and Technology, 32(4), 589–600