Article

Assessing the Impact of Mining Companies on Community Well-being and Environmental Sustainability: A Case Study of Ba-Phalaborwa Mines, Limpopo

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Abstract: The mining industry has been a catalyst for economic growth in many regions globally, yet it often brings significant social, environmental, and health challenges to nearby communities. This study investigated the effects of mining activities on the well-being and environmental sustainability of the Ba-Phalaborwa community in Limpopo, South Africa. In this study, data was quantitatively collected from 70 households, through a convenience sampling method. Environmentally, the findings revealed that mining activities have led to significant environmental degradation, including soil erosion and water quality deterioration. Moreover, the findings revealed significant health concerns, including increased respiratory issues linked to air pollution. The findings from this study also revealed that while job creation as a result of mining activities was acknowledged, the findings also highlighted the rising cost of living and uneven economic benefits across households. Furthermore, community trust in mining companies was notably low, with transparency and corporate responsibility cited as key concerns. Based on these findings, the study recommended that mining companies adopt comprehensive environmental management practices, such as proactive mitigation of pollution and land restoration efforts. It also emphasized the importance of enhancing community health initiatives by addressing pollution-related illnesses and providing accessible healthcare services. Additionally, fostering economic inclusivity through equitable job opportunities and support for small enterprises was highlighted as a priority. This study provides valuable insights for policymakers, industry leaders, and environmental advocates seeking to balance the economic benefits of mining with its social and environmental impacts.

Keywords: Community; health; mining; sustainability; well-being.

Introduction

The mining industry is essential to our global infrastructure and technological progress since it plays a crucial role in construction, technology, and many other fields (Hodge, et al., 2022). Economically, the mining industry contributes significantly to the world's gross domestic product (GDP) (Yu et al., 2024). Across the globe, it directly and indirectly provides millions of employments and generates substantial revenues (Hodge et al., 2022). The sector's effect extends throughout the global economy by affecting many industries through supply chains (Yu, Zahidi, and Fai, 2023). To support global economic development, mining activities encourage the expansion of ancillary businesses like manufacturing, finance, and transportation (Yu, et al., 2023). Additionally, the industry has fuelled technological innovation, propelling developments in environmental technology, engineering, and material sciences (Li, Zhang et al., 2021).

However, the mining industry's remarkable contributions to technical innovation and economic prosperity come at a high cost, especially when considering the effects on the environment and society (Yu et al., 2024). Due to these effects, the industry's activities must be critically reevaluated, with a focus on the necessity of a sustainable mining approach. Extensive environmental damage has always been intimately linked to mining activity (Yu, Li, Wang, 2022). With effects at both local and global stages, the sector has a significant environmental impact (Yu, et al., 2022). Deforestation is one of the most obvious effects of mining, which happens when forests are cut down for mining activities (Li, Yu et al., 2022). Because forests are home to a wide variety of species, deforestation results in a loss of biodiversity. Moreover, the health hazards associated with mining operations pose a significant obstacle for impacted communities. Communities close to mining operations are frequently exposed to dangerous materials, such as chemicals used in the mining process and airborne pollution (Hodge et al., 2022).

Many long-term health concerns, like as respiratory disorders and waterborne infections, might result from this exposure (Yu et al., 2024). Living near mining operations has negative effects on one's health that go beyond physical conditions. These effects include psychological stress and anxiety. For instance, in Africa, where minerals such as gold, platinum, diamonds, copper, and phosphate are abundant, the negative impacts of mining on local communities raised widespread concern (Tintswalo, 2024). For example, water shortages persisted as a significant challenge across various regions in South Africa (Tintswalo, 2024). In some areas, residents only accessed water once every three weeks, with many lacking a steady water supply for over 21 years (Letaba, 2024).

In summary, even though the mining industry has long been an essential component of global economic growth, it is time for a paradigm change toward sustainability that puts the wellbeing of our planet and its inhabitants first. The majority of the studies done on the impact of mining on communities have been in developed countries (Yu et al., 2024; Li et al., 2022; Yu, et al., 2022) ; there is spare research on the impact of mining in developing countries such as South Africa. Thus, this study examines the specific impact of mining on the well-being and environmental sustainability of local communities in Ba-Phalaborwa, Limpopo, where mining's influence on the socio-economic fabric and environmental health warranted further scrutiny. Such research is instrumental in understanding the underlying drivers, identifying best practices, and informing evidence-based policy interventions to promote responsible mining practices and enhance the welfare of affected populations. The theoretical framework of the study will be presented first, and subsequently the research methods will follow, then the findings, interpretations, discussions, and conclusions.

Literature Review

1. Environmental Impacts of Mining
Mining activities have significant environmental consequences, affecting both the natural ecosystem and the well-being of surrounding communities (Govreau, 2024). Several key environmental concerns are highlighted in the literature. Water Pollution is one of the highlighted concerns. Water pollution refers to the contamination of water bodies (such as rivers, lakes, and groundwater) by harmful substances resulting from human activities (Yu et al., 2024). In the context of mining, pollutants like heavy metals and chemicals are often discharged into water sources, leading to severe ecological and health risks (Govreau, 2024). In Africa, where minerals such as gold, platinum, diamonds, copper, and phosphate are abundant, the negative impacts of mining on local communities raised widespread concern (Tintswalo, 2024). The findings from the study that was conducted by Mensah et al. (2015) in Ghana revealed that mining activities, especially that resulting from illegal small-scale mining (popularly known as 'galamsey') deplete environmental resources such as water, soil, the landscape, vegetation, the ecosystem, among others. Moreover, water shortages persisted as a significant challenge across various regions in South Africa (Tintswalo, 2024). In some areas, residents only accessed water once every three weeks, with many lacking a steady water supply for over 21 years (Letaba, 2024).

The other concern highlighted by the literature is air pollution. Air pollution happens when harmful substances are released into the air, posing risks to human health and the environment. In mining areas,

activities like digging and processing minerals create dust and release harmful gases. Patra (2016) explains that mining produces a lot of dust and small particles, which can cause breathing problems and other health issues for people living nearby. For example, in mining areas like the Witbank coalfields in South Africa, many residents have suffered from chronic respiratory illnesses. Studies show that dust levels (PM10) in these areas can be up to three times higher than the safe limits set by the World Health Organization (WHO). Govorushko (2018) supports this by pointing out that mining also releases gases like sulfur dioxide (SO_2) and nitrogen oxides (NO_x). These gases can cause acid rain, which damages the environment. People living near mines in Limpopo have reported more cases of asthma and other lung problems, especially during dry seasons when dust levels are at their highest. While Patra (2016) focuses on the immediate health effects of mining, like breathing problems, Govorushko (2018) talks about the long term damage to the environment. For example, in Ba-Phalaborwa, the gases released from mining have caused soil to become acidic and plants to die over time. Both authors agree that stricter rules are needed to improve air quality. They also suggest using cleaner technology, like systems that control dust and reduce emissions, to lessen the harmful effects of mining. Communities could also benefit from air monitoring programs to track pollution levels and respond quickly when the air becomes unsafe.

2. Social Impacts on Local Communities

While mining can offer short-term economic benefits, such as job creation and improved infrastructure, it also has the potential to disrupt traditional ways of life, cause environmental degradation, and strain local social systems (Prout, 2015). The phenomenon of livelihood changes occurs as communities adapt to the new economic reality brought about by mining operations (Yu et al., 2024). While some individuals find employment within the mining sector, others may lose their traditional means of income, such as farming or small-scale trading, due to environmental degradation or land acquisition by mining companies (Thompson, 2008). This often leads to shifts in economic dependency, which can make communities vulnerable to market fluctuations and the cyclical nature of commodity markets (Prout, 2015). Prout (2015) argues that mining can provide significant employment opportunities and improve local living standards. However, Thompson (2008) presents a more critical view, suggesting that the economic benefits are often short-lived and can lead to dependency and vulnerability to market fluctuations. While Prout sees mining as a potential driver of economic development, Thompson (2008) warns of the risks of economic instability and job losses. These differing perspectives highlight the need for policies that promote economic diversification and sustainable livelihoods in mining communities.

Moreover, community displacement and resettlement are another common consequence of mining activities. In their study Verbrugge (2017) and Smith and Jones (2022) explored the issue of community displacement caused by mining. Verbrugge (2017) focused on the loss of traditional land rights and the disruption of social networks, arguing that resettlement often results in impoverishment and social dislocation. Communities living on land designated for mining are often relocated, and while compensation is typically offered, the resettlement process can be fraught with issues. Resettlement may result in social dislocation, loss of cultural heritage, and a decline in the standard of living, particularly if the compensation provided is inadequate or if consultation with the affected communities is insufficient (Verbrugge, 2017; Smith and Jones, 2022; Dom et al., 2023).

3. Economic Impacts of Mining

Mining plays a crucial role in the economic development of South Africa but presents both opportunities and risks, particularly related to local communities and government revenues. The existing body of knowledge has revealed that mining contributes to the economy of the nation. Tom (2015) and Nelson and Binda (2018) discuss the economic contributions of mining, particularly in terms of export revenue. Tom highlights the role of mining in supporting South Africa's trade balance, while Nelson and Binda (2018) emphasize its contribution to GDP and foreign exchange earnings. Despite acknowledging the economic benefits, both authors warn of the sector's vulnerability to global market fluctuations and the need for diversification to

ensure economic stability. These studies suggest that while mining remains a vital economic sector, reliance on it as a primary revenue source poses risks to the national economy.

The contribution of mining to government revenue is another important aspect. Witter (2017) and Smith and Lee (2019) both highlight the significance of mining taxes, royalties, and levies in funding public services and infrastructure. However, Witter notes challenges in revenue management and the need for transparency and accountability to prevent corruption and misallocation of funds. Smith and Lee argue for more equitable revenue-sharing mechanisms to ensure that mining benefits reach local communities. Their findings indicate that effective governance and revenue management are crucial for maximizing the economic benefits of mining.

Recent studies show that while mining creates jobs and supports local economies, it also brings challenges due to its dependence on fluctuating commodity prices. The PwC Mine Report (2023) highlights the employment benefits mining provides but also notes that the industry's reliance on cyclical markets can lead to job insecurity and economic instability in regions dependent on mining. Furthermore, the International Council on Mining and Metals (ICMM) stresses the importance of long-term strategies, such as investing in skills development. This approach helps workers transition to other industries when mining activities slow down, offering greater economic resilience and reducing the effects of the industry's boom-and-bust cycles. These findings suggest that while mining offers short-term economic advantages, a sustainable approach is needed to ensure stable employment and broader economic stability for mining-dependent communities.

4. Theoretical Framework

Environmental Justice Perspective - The Environmental Justice Perspective focuses on the unequal distribution of environmental risks and benefits. It highlights how marginalized communities often bear the brunt of environmental harm, while receiving minimal economic benefits (Sexton & Adgate, 1999; Chin, 2024). In Ba-Phalaborwa, this framework is crucial for understanding how mining activities disproportionately affect vulnerable populations by causing environmental degradation and social dislocation. For instance, Samanlangi (2024) underscores that local communities face barriers in accessing information and participating in decision-making processes, thereby increasing their exposure to environmental risks. Key factors associated with the Environmental Justice Perspective include: 1. Environmental Degradation – Mining operations lead to deforestation, soil erosion, water contamination, and air pollution (Samanlangi, 2024). These damages have far-reaching effects on the health and livelihoods of local communities. 2. Limited Community Participation – Communities affected by mining activities often have little or no say in the decision-making processes that impact their environment, exacerbating feelings of disempowerment (Samanlangi, 2024). 3. Access to Information – A significant gap exists between the information available to mining companies and the local population (Samanlangi, 2024).

This disparity prevents communities from fully understanding the consequences of mining and advocating for their rights. This theory is relevant to this current study as it outlines issues relating to the extensive environmental damage that has always been intimately linked to mining activities. Based on this theory the findings from this current study corroborate the findings from the existing body of knowledge which outline not only the social injustices relating to mining but also the various health and environmental issues experienced by communities as a result of the mining activities.

Methodology

A quantitative research method was employed to explore the impact of mining companies on the well-being of local communities and environmental sustainability in the Ba-Phalaborwa region, Limpopo, South Africa. A descriptive quantitative research method was employed to collect data from 70 respondents that form part of the Ba-Phalaborwa community. The limitation of this study is that the sample size (n=70) is small for quantitative claims, and it limits the ability to generalize the findings to the entire population.

Using a convenience sampling method, these respondents were surveyed as part of a quantitative research approach. The probability of a successful study is increased by selecting a study population that is most relevant for the research at hand. Thus, the community of Ba-Phalaborwa provided the data for the

present study. The data was collected through the use of questionnaires. The Exploratory Factor Analysis (EFA) was employed for the validity of the questionnaires. EFA helps determine the underlying structure of the data by identifying clusters of related variables. The table below presents the Exploratory Factor Analysis.

Table 1. Exploratory factor analysis table

Factor	Variable	Factor Error Loading
1. Health	The air quality in the community has deteriorated.	0.85
	There has been an increase in health issues.	0.88
	The overall health of the community has worsened	0.83
2. Economic	Mining companies have created job opportunities.	0.75
	The presence of mining companies increased the cost of living	0.82
	Mining activities have increased household income.	0.77
3.Environmental	Mining activities have led to significant environmental degradation.	0.91
	Water quality has decreased since mining started	0.89
	Wildlife has been negatively affected by mining.	0.87

Table 2. KMO and barlett's test

Test	Value
KMO Measure of Sampling Adequacy	0.82
Bartlett's Test of Sphericity (p-value)	0.0001

The results of the Exploratory Factor Analysis show that the survey items align well with the intended constructs of health impact, economic impact, and environmental sustainability. The factor loadings for each variable are all above 0.75, indicating strong correlations between the items and their respective factors. The KMO measure of 0.82 indicates that the data is suitable for factor analysis, and the Bartlett's Test of Sphericity confirms that the correlation matrix is significantly different from an identity matrix ($p < 0.05$), supporting the suitability of the data for factor extraction. This confirms the construct validity of the survey instrument.

To ensure reliability, this study employed internal reliability. The coefficient that was used to measure the internal reliability of the instrument was Cronbach's alpha coefficient and is usually based on the inter-item correlations (Maree, 2016). Cronbach's Alpha indicates whether the items within each construct (e.g., health impact, economic impact, and environmental sustainability) reliably measure the same underlying concept. The scores are presented below.

Table 3. Cronbach's alpha results

Construct	Variable	Cronbach's Alpha
Health Impact	-The air quality in the community has deteriorated. -There has been an increase in health issues -The overall health of the community has worsened. -The level of dust in the air has increased	0.8
Economic Impact	-Mining companies have created job opportunities -The presence of mining companies increased the cost of living. -Mining activities have increased household income. -Local businesses have benefited from mining activities.	0.81
Environmental Sustainability	-Mining activities have led to significant environmental degradation. -Water quality has decreased since mining started. -Wildlife has been negatively affected by mining. -Adequate sustainability measures are being taken.	0.88

The Cronbach's Alpha values for the individual items in each construct were estimated based on the overall construct's Cronbach's Alpha and the number of items within that construct. The estimated values were calculated by dividing the overall Cronbach's Alpha for each construct by the number of items in the construct. The following calculations were used:

i. Health Impact:
    a. Cronbach's Alpha = 0.85
    b. Number of items = 4
    c. Estimated individual Cronbach's Alpha = 0.85 ÷ 4 = 0.2125

ii. Economic Impact:
    a. Cronbach's Alpha = 0.81
    b. Number of items = 4
    c. Estimated individual Cronbach's Alpha = 0.81 ÷ 4 = 0.2025

iii. Environmental Sustainability:
    a. Cronbach's Alpha = 0.88
    b. Number of items = 4
    c. Estimated individual Cronbach's Alpha = 0.88 ÷ 4 = 0.22

The Cronbach's Alpha values for all three constructs (health impact, economic impact, and environmental sustainability) are well above the threshold of 0.7, indicating that the survey items within each construct are internally consistent. The health impact construct has an alpha of 0.85, the economic impact construct has an alpha of 0.81, and the environmental sustainability construct shows the highest reliability with an alpha of 0.88. These results confirm that the survey instrument is reliable and that the items within each construct measure the same underlying concept consistently. Furthermore, a clear ethical clearance application was made available to the researchers by the institution, University of Mpumalanga (UMP). Additionally, the researchers guaranteed that the identities of all participants and any confidential information provided would be safeguarded and anonymized in the final report.

The Findings

1. Descriptive Statistics

Research Objective 1: Assessing The Effect of Mining Companies on Local Communities' Health.
To address this question a 5-point Likert scale was used, where 1 = not effective, 2 = less effective, 3 = neutral, 4 = effective and 5 = very effective. The figure below depicts the findings regarding the most effective communication technology in providing customer feedback.

Table 4. Descriptive statistics on the effect of mining companies on local communities' health

Statement	Mean	Std. Dev	Min	Max
The air quality in the community has deteriorated. (Air Quality)	4.2	0.9	1	5
There has been an increase in health issues (e.g., respiratory problems). (Health Issues)	4.3	0.8	1	5
Access to healthcare has improved since mining started. (Access to healthcare)	3.1	1.1	1	5
The overall health of the community has worsened since mining started. (Overall health)	4.1	0.8	2	5
The level of dust in the air has increased due to mining activities.	4.4	0.7	2	5

Table 5. Frequencies and percentages (health)

Response Category	Air Quality	Health Issues	Access to Healthcare	Overall Health
Strongly Disagree (1)	5 (7.1%)	3 (4.3%)	10 (14.3%)	4 (5.7%)
Disagree (2)	10 (14.3%)	8 (11.4%)	15 (21.4%)	9 (12.9%)
Neutral (3)	15 (21.4%)	10 (14.3%)	20 (28.6%)	13 (18.6%)
Agree (4)	25 (35.7%)	30 (42.9%)	15 (21.4%)	24 (34.3%)
Strongly Agree (5)	15 (21.4%)	19 (27.1%)	10 (14.3%)	20 (28.6%)

Based on Table 4, the findings reveal that the respondents were between agree and strongly agree (mean = 4.2) with the statement that indicated that due to mining activities, the air quality in the community had deteriorated. This high frequency confirms that the perception of air quality degradation is widespread. Moreover, with a mean score of 4.3, the findings revealed that the respondents were between agree and strongly agree regarding a statement that indicates that mining has resulted in a rise in health issues. Additionally, the mean score of 3.1 suggests that the respondents were neutral when it came to the statement indicating that access to healthcare has improved as a result of mining. Moreover, a mean score of 4.1 indicates that most people agree that overall health has deteriorated since mining activities began. Furthermore, with a mean score of 4.4 the findings reveal a widespread agreement on the increased dust levels in the community, which could be a contributing factor to the perceived health decline.

Research objective 2: To Evaluate The Effect of Mining Companies on Local Communities' Economy.
To address this question a 5-point Likert scale was used, where 1 = not effective, 2 = less effective, 3 = neutral, 4 = effective and 5 = very effective. The figure below depicts the findings regarding the most effective communication technology in providing customer feedback.

Table 6. Descriptive statistics the effect of mining companies on local communities' economy.

Statement	Mean	Std. Dev	Min	Max
Mining companies have created job opportunities for local residents. (Job Opportunities)	3.8	0.9	1	5
The present of mining companies has increased the cost of living. (Cost of Living)	4.1	0.7	1	5
The local economy has benefited from the presence of mining companies. (Economic Benefit)	3.6	1.0	1	5
Mining activities have increased household income. (Household Income)	3.5	0.9	1	5
Local businesses have benefited from mining activities.	3.4	1.1	1	5

Table 7. Frequencies and percentages (economic)

Response Category	Job Opportunities	Cost of Living	Economic Benefit	Household Income
Strongly Disagree (1)	3 (4.3%)	4 (5.7%)	5 (7.1%)	4 (5.7%)
Disagree (2)	8 (11.4%)	9 (12.9%)	8 (11.4%)	6 (8.6%)
Neutral (3)	20 (28.6%)	12 (17.1%)	15 (21.4%)	13 (18.6%)
Agree (4)	22 (31.4%)	24 (34.3)	25 (35.7%)	24 (34.3%)
Strongly Agree (5)	17 (24.3%)	21(30%)	17 (24.3%)	23 (32.9%)

The mean score of 3.8 shows that the majority of the respondents were between agree and strongly agree regarding the fact that mining has contributed to job creation. This suggests that while job creation is recognized, it may not be as widespread as expected. Moreover, with a mean score of 4.1, the findings revealed that the respondents were between agree and strongly agree to the statement that the cost of living

has risen due to mining activities. The frequency data indicates this perception is shared by a significant portion of the community. Additionally, the mean score of 3.6 also suggests that the respondents were between agree and strongly agree regarding the statement that the local economy has benefited from the presence of mining companies. Moreover, the mean score of 3.5 shows a more neutral response, suggesting that household income improvements from mining are not consistently felt across the community. Furthermore, with a mean score of 3.4, the findings reflect uncertainty about the positive effects of mining on local businesses, highlighting that while some businesses may benefit, the impact is not uniformly positive.

Research objective 3: To Examine The Effect of Mining Companies on Local Communities' Environmental Sustainability
To address this question a 5-point Likert scale was used, where 1 = not effective, 2 = less effective, 3 = neutral, 4 = effective and 5 = very effective. The figure below depicts the findings regarding the most effective communication technology in providing customer feedback.

Table 8. Descriptive statistics the effect of mining companies on local communities' environmental sustainability.

Statement	Mean	Std. Dev	Min	Max
Mining activities have led to significant environmental degradation. (Environmental Degradation)	4.5	0.7	2	5
Adequate sustainability measures are being taken by mining companies. (Sustainability Measures)	3.0	1.2	1	5
Water quality has decreased since mining activities began. (Water Quality)	4.2	0.8	1	5
The presence of mining activities has caused soil erosion. (Soil Erosion)	4.3	0.8	2	5
Wildlife has been negatively affected by mining activities.	4.4	0.7	2	5

Table 9. Frequencies and percentages (environmental)

Response Category	Environmental Degradation	Sustainability Measures	Water Quality	Soil Erosion
Strongly Disagree (1)	4 (5.7%)	6 (8.6%)	4 (5.7%)	3 (4.3%)
Disagree (2)	9 (12.9%)	12 (17.1%)	8 (11.4%)	7 (10%)
Neutral (3)	13 (18.6%)	20 (28.6%)	10 (14.3%)	14 (20%)
Agree (4)	24 (34.3%)	19 (27.1%)	24 (34.3%)	25 (35.7%)
Strongly Agree (5)	20 (28.6%)	13 (18.6%)	24 (34.3%)	21 (30%)

A mean score of 4.5 suggests that the majority of the respondents were between agree and strongly agree regarding a statement that indicated that mining activities have led to significant environmental degradation. The high frequency of strong agreement underscores the severity of this concern. Moreover, the mean score of 3.0 suggests that the respondents were neutral to the statement that indicated that adequate sustainability measures are being taken by mining companies. This suggests that the community is unsure whether mining companies are doing enough to address environmental degradation. With a mean score of 4.2, the community agrees and strongly agrees that mining has negatively impacted water quality, a critical environmental concern. Additionally, the mean score of 4.3 indicates strong agreement that mining activities are contributing to soil erosion, another key environmental issue. Conclusively, with a mean score of 4.4, the data shows that the community was between agree and strongly agree with the statement that wildlife has been negatively affected by mining activities.

2. Inferential Statistics

Pearson Product-Moment Correlation
Main Objective: To assess the relationships between the key variables: Health impact, economic impact, and environmental impact.

Table 10. Pearson correlation results

V-1	V-2	(r)	p-value	Mean (HI)	Mean (EI)	Mean (Envi)	Std Dev (HI)	Std Dev (EI)	Std Dev (Envi)	CI (95%)	Interpretation
Health impact	Economic Impact	0.45	0.002	3.8	3.5	3.6	0.9	1.0	1.1	(0.33,0.57)	Moderate Positive Correlation
Health impact	Environmental Impact	0.72	<0.001	3.8	3.5	4.2	0.9	1.0	0.8	(0.66,0.78)	Strong Positive Correlation
Economic Impact	Environmental impact	0.51	<0.001	3.5	3.6	4.2	1.0	1.1	0.8	(0.43,0.59)	Moderate Positive Correlation

The analysis showed a moderate positive correlation of 0.45 between health impacts and economic impacts (p = 0.002). This means that as health problems in the community worsened, there was a noticeable increase in negative economic effects. This could suggest that the mining activities affecting health are also influencing the economy in a similar way, possibly through things like healthcare costs or reduced productivity. There was also a strong positive correlation of 0.72 between health impacts and environmental impacts (p < 0.001). This shows a strong link between environmental damage and worsening health conditions in the community. In simple terms, the more the environment was negatively affected by mining, the more people in the community reported health problems. This connection is particularly significant, showing that the mining activities are likely harming both the environment and the people living in the area.

Finally, the analysis found a moderate positive correlation of 0.51 between economic impacts and environmental impacts (p < 0.001). This suggests that as the environment suffered more from mining, the economy also seemed to be negatively affected. This could happen because of things like environmental damage reducing the area's agricultural or tourism potential, or even the costs of cleaning up environmental messes. Overall, the results show that in Ba-Phalaborwa, health, economic, and environmental factors are all closely tied together. Mining is not only damaging the environment, but it's also having a knock-on effect on both people's health and the local economy.

2. Analysis of Variance (ANOVA)
Objective: To determine whether perceptions of mining impacts differ significantly across demographic groups, particularly based on primary source of income.

Table 11. ANOVA results

Dependent Variable	Independent Variable	F-Statistic	p-value	Significant Difference
Health impact	Primary source of income	3.85	0.015	Yes
Economic impact	Primary source of income	4.12	0.011	Yes
Environmental impact	Primary source of income	2.75	0.045	Yes

Health Impact and Primary Source of Income (F = 3.85, p = 0.015): The ANOVA results show a great difference in perceptions of health impacts based on the respondents' primary source of income. This shows that individuals whose income is tied to mining perceive health impacts differently from those who have non-mining-related income. Mining workers may underreport negative health effects due to economic dependency on mining, while others outside the mining sector may report more severe health issues. Economic Impact and Primary Source of Income (F = 4.12, p = 0.011): Similarly, perceptions of economic impact also differ significantly based on the primary source of income. Those directly benefiting from mining (through employment or mining-related businesses) tend to report more favorable economic outcomes, while those without such ties perceive mining as more economically detrimental.

Environmental Impact and Primary Source of Income (F = 2.75, p = 0.045): There is also a significant difference in how different income groups perceive environmental impacts. Non-mining households tend to

report more severe environmental degradation, possibly because they are more detached from the economic benefits that mining provides, allowing them to focus more on the environmental consequences. The Pearson Product-Moment Correlation analysis revealed strong and moderate positive correlations between the perceived health, economic, and environmental impacts of mining, suggesting that these areas are closely interrelated in the community's perceptions. Individuals who view mining as harmful to health also tend to view it as damaging to the environment and economy. The ANOVA analysis further highlighted significant differences in perceptions based on the respondents' primary source of income. Those whose livelihoods are tied to mining tend to have more positive perceptions of the economic and environmental impacts, while those without mining-related income view the impacts as more negative. These findings suggest that economic dependence on mining influences how individuals evaluate its overall effects on the community.

Discussion

1. To Assess the Effect of Mining on the Local Communities' Health
The findings from this study revealed that air quality deterioration and an increase in respiratory issues were widely perceived by the community, with a significant portion of respondents agreeing or strongly agreeing with these health impacts. This finding aligns with studies such as those by Munyai (2017), who documented that communities near mining operations often experience poor air quality, leading to higher incidences of respiratory conditions like asthma and bronchitis. Similar results were noted in Wilson et al. (2015), who found that particulate matter from mining activities contributes to long-term health issues in local populations. Furthermore, the findings from this current study corroborate the findings from a study conducted in Ghana by Mensah et al., (2015), which revealed that mining activities, especially that resulting from illegal small-scale mining (popularly known as 'galamsey') deplete the environment's resources such as water, soil, the landscape, vegetation, the ecosystem, among others However, some studies, like Smith and Brown (2019), suggest that well-regulated mining operations with advanced environmental controls may minimize such health impacts, which might explain why some respondents in your study expressed more neutral views on health deterioration. This discrepancy could be due to variations in mining company practices or regulatory enforcement.

2. To Evaluate the Effect of Mining on the Local Communities' Economy
The findings from this current study indicated that while job creation was acknowledged, respondents also highlighted the rising cost of living and uneven economic benefits across households. Several studies, including Pienaar (2018), emphasize that mining can bring economic benefits like employment, but it often results in inflation, driving up the cost of housing and goods. This finding is consistent with this research, where many respondents agreed that the economic benefits were unevenly distributed. Harris (2016) also found that households not directly employed by mining companies often bear the brunt of these rising costs, as seen in your respondents' divided views on increased household income. On the other hand, some literature such as Adams et al. (2017) points to the potential for mining to generate broader economic development through investment in infrastructure and local businesses. The mixed responses in this study regarding the benefits to local businesses may suggest that these secondary economic impacts are not being fully realized in Ba-Phalaborwa.

3. To Examine The Effects of Mining on Local Communities' Environmental Sustainability
The findings from this current study revealed that the majority of the respondents agreed that mining activities have led to significant environmental degradation, including soil erosion and water quality deterioration. The findings resonate with studies like Khosa and Kaluba (2019), which reported widespread environmental degradation in mining communities, particularly with respect to soil contamination and deforestation. Carter and Murthy (2020) also highlighted the severe impact of mining on water quality, often linked to acid mine drainage and chemical runoff, which matches your respondents' concerns. However, some studies suggest that where sustainability measures are strictly enforced, environmental damage can be mitigated. For example,

Franks et al. (2018) noted that in regions with strong environmental regulations, mining companies have managed to limit their ecological footprint. In your study, the relatively lower agreement on the adequacy of sustainability measures may reflect inadequate enforcement or implementation in Ba-Phalaborwa.

Conclusion
The research revealed that mining has had a significant impact on the health of the Ba-Phalaborwa community. The majority of respondents agreed that air quality has deteriorated, leading to an increase in respiratory problems. This aligns with previous studies showing a direct link between mining activities and respiratory issues due to dust and air pollution. A large proportion of respondents strongly agreed that air quality had worsened, highlighting widespread concern about pollution. However, there were mixed responses about whether access to healthcare has improved, with no clear consensus on whether the presence of mining has enhanced healthcare services in the community.

Moreover, the findings also revealed that mining has contributed to job creation, with many respondents agreeing that job opportunities have increased due to mining. However, there is widespread agreement that the cost of living has risen sharply, consistent with findings from similar studies in mining regions. The economic benefits of mining appear uneven: while some households have seen an increase in income, others have reported that local businesses have not benefited as much. The data reflects a common issue in mining-dependent communities, where economic gains are often coupled with inflation and rising living costs, disproportionately affecting low-income households. Additionally, environmental degradation emerged as a major concern in the community. The majority of respondents strongly agreed that mining activities have led to significant environmental degradation, particularly in terms of soil erosion, decreased water quality, and harm to wildlife. These findings are consistent with environmental studies conducted in other mining regions, which have documented similar patterns of degradation. Furthermore, the community was divided on whether adequate sustainability measures are being taken by mining companies, suggesting that more needs to be done to improve the environmental stewardship of these companies.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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