Journal of Agriculture & Environmental Sciences

Evaluation of the Effectiveness of Environmental and Social Impact Assessment Compliance on the Mining Sector in Rwanda

Mugoboka Y., Kamuhanda. J.K., Jacques N., & J.O. Ihuma

ISSN: 2616-8556

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

Evaluation of the Effectiveness of Environmental and Social Impact Assessment Compliance on the Mining Sector in Rwanda

[1]Mugoboka Y; [1]Kamuhanda. J.K ; [2,3]Jacques N., and [1,4]J.O. Ihuma
Faculty of Environmental Studies, University of Lay Adventists of Kigali, P.O. Box. 6392, Kigali, Rwanda
yvesmugoboka5@gmail.com
[1]Kamuhanda. J.K ;
Faculty of Environmental Studies, University of Lay Adventists of Kigali, P.O. Box. 6392, Kigali, Rwanda
kamuhanda.jkant@unilak.ac.rw
[2,3]Jacques N.,
[2]Atlantic International University (AIU), USA, Hawaii, IUPioneer Plaza, 900 Fort Street Mall 905, Honolulu, HI 96813, 800-993-0066
[3]CS NJEMA Ltd, Kigali, Rwanda, REMERA, KK11 AVE, Ikaze House, 5th Floor, Door 8
nsengiyumvajacques@gmail.com
[1,4]J.O. Ihuma
Faculty of Environmental Studies, University of Lay Adventists of Kigali, P.O. Box. 6392, Kigali, Rwanda
[4]Faculty of Science and Technology, Department of Biological Science, Bingham University, Karu, Nasarawa State, Nigeria
Jeromeihuma@binghamuni.edu.ng

How to cite this article **: Mugoboka Y., Kamuhanda J.K., Jacques N., & Ihuma J.O. (2025). Evaluation of the Effectiveness of Environmental and Social Impact Assessment Compliance on the Mining Sector in Rwanda.** ***Agriculture & Environmental Sciences. Vol*** **9(3) pp. 1-15 https://doi.org/10.53819/81018102t2488**

Abstract

This research evaluates the mining sector of Rwanda in terms of compliance, enforcement challenges and implementation of the Environmental and Social Impact Assessment (ESIA) regulatory requirements. As at 2022, the sector was one of key economic drivers contributing hugely about $733 million in exports and 3.6% of GDP to the growth, however, the sector is undoubtedly grappling with obvious environmental and social challenges. The effectiveness ESIA compliance in the mining sector was evaluated using a mixed-methods approach, integrating qualitative and quantitative data from the government, companies, and communities. Data were analyzed using frequencies, percentages, means, regression and correlation analysis. The results indicated that males across all age groups constituted 62% of the miners while female constituted only 38% demonstrating a higher participation of males in the mining sector compared to females. Also, various levels of inconsistency in compliance with proper ESIA procedures and guidelines

were observed with only 28% of the companies in Full Compliance (FU), 48% Partial Compliance (PC), and 24% showed Non-Compliance (NC). It was also observed that a statistically significant negative correlation was observed between deforestation and ESIA compliance ($r = -0.62$, $p < 0.01$), and a strong inverse relationship was found between ESIA compliance and water contamination ($r = -0.58$, $p < 0.01$). Similarly, a stronger ESIA enforcement corresponds with lower biodiversity loss ($r = -0.55$, $p < 0.01$). ESIA compliance and stakeholder participation were correlated and the result showed ($r = 0.67$, $p < 0.01$), also, the relationship between ESIA compliance and conflict reduction was ($r = -0.54$, $p < 0.05$). Again, significant positive relationship between ESIA compliance and mining sector profitability ($\beta=0.42$, $p<0.01$ & beta = 0.42, $p < 0.01$ $\beta=0.42$, $p<0.01$) was observed. While ESIA compliance initially imposes higher operational costs, the regression analysis indicated that it ultimately results in long-term cost savings ($\beta=-0.38$, $p<0.05$ & beta = -0.38, $p < 0.05$ $\beta=-0.38$, $p<0.05$). The findings highlighted a strong association between ESIA compliance and a company's market reputation ($\beta=0.55$, $p<0.01$ & beta = 0.55, $p < 0.01\beta=0.55$, $p<0.01$). The study recommends strengthening regulatory oversight, implementing digital compliance tracking, enhancing community participation, and enforcing stricter penalties for non-compliance. Addressing these challenges is essential for aligning Rwanda's obligated best practices in the mining sector with Vision 2050 and the Sustainable Development Goals (SDGs), ensuring responsible resource management, proper environmental conservation, and responsible social justice.

Key words : *Mining, Compliance, Environment, Sustainability, Impact, Assessment*

1. Introduction

Environmental standards are put in place by government, people, regulatory bodies, and environmental advocates for compliance to avoid, prevent, and reduce any negative consequences of exploration on the environment and, to a larger extent, human beings. Exploration includes prospecting for hydrocarbons, earth metals, and other mineral deposits from their natural pools. In Rwanda, the mining sector is a cornerstone of economic development, contributing significantly to the gross domestic product (GDP), employment, and foreign exchange earnings. For instant, in 2021 (Fig.1), the sector accounted for 3.6% of the GDP and was ranked as the second-largest export revenue contributor, generating over $733 millions (Rwanda Economic indicators, 2021). Minerals like tin, tantalum, and tungsten have traditionally driven Rwanda's mining economy, representing nearly 60% of mineral exports, and have expanded the sector's significance in national development. Mining activities also stimulate infrastructure improvements, including transportation, energy, and water access in remote areas (African Bank development, 2021).

However, mining, a resource-intensive activity, disrupts natural ecosystems and perturb landscapes and in Rwanda, it has also created substantial environmental and social inpact challenges. Between 2010 and 2020, mining-related deforestation accounted for 15% of Rwanda's forest lost, Water pollution from mining affects nearly 20% of the country's freshwater systems, with contaminants like sediments and heavy metals threatening aquatic life and clean water availability for 250,000 rural residents (Mukamana, 2020). Additionally, soil erosion from mining operations has reduced agricultural productivity, intensifying food insecurity near mining sites.

The social impacts of mining present a mixed picture. While the sector directly employs over 40,000 workers, 80% who are in artisanal and small-scale mining, concerns remain over community displacement, labor exploitation, and unsafe working conditions (Nsabimana A. &

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

Habumugisha T, 2021). For instance, in 2019, over 1,200 households were displaced due to mining activities, often with insufficient compensation or consultation, leading to disrupted livelihoods and weakened social cohesion. Child labor also persists, with nearly 10% of children in mining regions involved in mining-related tasks. To mitigate these negative impacts, Rwanda then established regulatory measures such as Environmental and Social Impact Assessments (ESIA). ESIA is designed to evaluate and manage the environmental and social effects of mining projects. It requires stakeholder consultation, environmental monitoring, and mitigation plans to be implemented before operations commenced (REMA, 2022). Rwanda's Environmental Organic Law (Law N° 48/2018) further solidifies the legal framework for ESIA, making it mandatory for large-scale industrial projects, including mining.

The global context further emphasizes the importance of ESIA compliance (Fig.2). As a signatory to the United Nations Sustainable Development Goals (SDGs), Rwanda is committed to achieving sustainable development, particularly through Goals 12 (Responsible Consumption and Production) and 15 (Life on Land), which call for sustainable resource management and ecosystem restoration (UN, 2015).

Despite these measures, gaps in ESIA implementation remain a huge problem due to inconsistencies in compliance. These implementation gaps highlight the disconnect between Rwanda's policy commitments and the realities on the ground. Therefore, this research evaluates the effects of ESIA compliance on Rwanda's mining sector, challenges, and outcomes to prescribe actionable recommendations for improving ESIA frameworks.

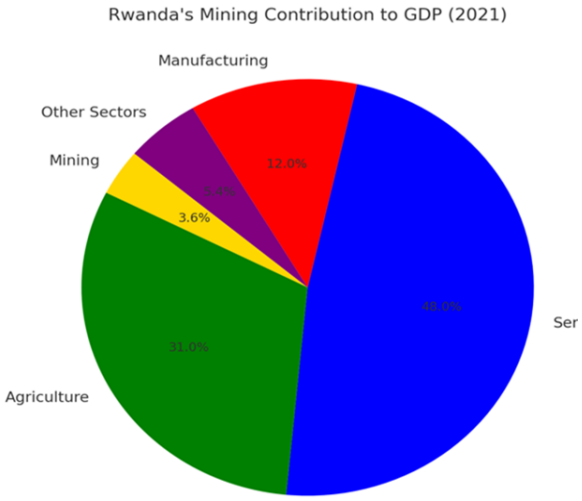

Fig. 1 : Contribution of Rwanda's Mining to GDP (2021)

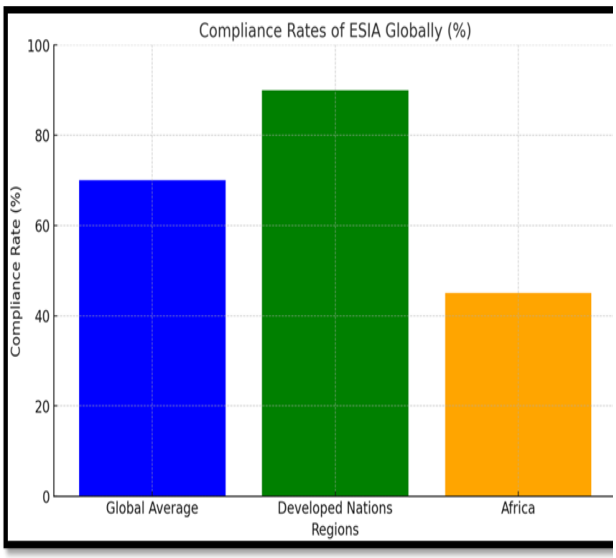

Fig. 2. Compliance rates of ESIA Globally

2. Materials and Methods

2.1 Description of the Study Areas

Rwanda, often called the land of a thousand hills, is in East-Central Africa (Fig1). The study regions are part of the Congo-Nile Divide, featuring rugged terrain, dense forests, and numerous

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

rivers that provide essential water sources for local ecosystems and communities. These areas sit at altitudes ranging from 1,500 to 3,000 meters above sea level and are characterized by a tropical climate with distinct wet and dry seasons (Smith, 2019).

The Western province borders the Democratic Republic of Congo, which adds a transboundary dimension to environmental and social impacts, especially regarding shared resources like Lake Kivu and the Rusizi River (fig. 2 &3). The Northern province is part of the Virunga massif, home to biodiversity hotspots that require proper management amid mining activities (Mukiza J. , 2020) and the Southern Province shares its borders with Burundi to the south, the Nyungwe Forest, located in the province, extends its ecological influence into Burundi, creating shared biodiversity zones that require collaborative conservation efforts.

The Eastern Province is bordered by Tanzania to the east, with the Akagera River serving as a natural boundary (fig. 2 &3). This region is characterized by expansive savannas, the Akagera National Park, and several wetlands that extend into Tanzania, making it a critical area for biodiversity conservation (Murekezi, 2019)

Figure 1 : Map of Rwanda.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

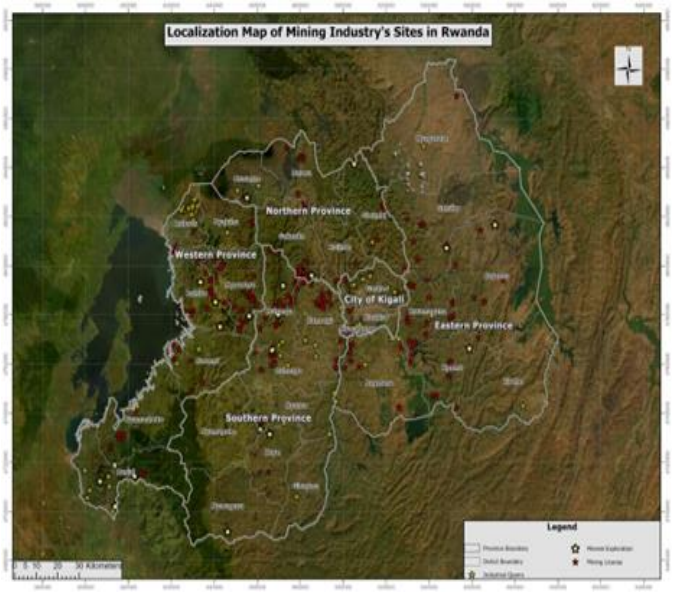

Figure 2 : Map of Mining sites in Rwanda.

Figure 3. Map of Mining Licenses in Rwanda.

2.2 Research Design and Data Collection

This research employed quantitative and qualitative designs to assess the impact of ESIA compliance on Rwanda's mining sector. The qualitative aspect captured the intricate experiences, perspectives, and practices of stakeholders, including mining operators, government officials, and local communities affected by mining activities. The quantitative aspect provided the empirical data on vital variables, such as rates of environmental degradation and indicators of social impact, which are crucial for validating the findings and identifying emerging trends. Data were also collected from literature review, interview and Focus Group Discussions (FGD).

As indicated in table 1 and Fig. 5 below, five (5) mining companies from each province, totaling Twenty five (25) companies out of the currently 136 active mining companies across Rwanda were sampled,

The sample size was obtained using Yamane's formula : $\boldsymbol{n = N/(1+N(e)2}$ where : n = the sample size ; N = the population of the study ; e = the margin error in the calculation=0.06. Data were analyzed using frequencies, percentages, means, regression analysis and correlation.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

Table 1 : Province, District and Number of Companies/Cooperatives,

S/No	Province	District	No of Companies/Cooperatives
1	Northern	Gakenke	2
		Burera	1
		Rulindo	2
2	Southern	Muhanga,	2
		Kamonyi	2
		Ruhango	1
3	Eastern	Rwamagana,	2
		Kayonza	2
		Bugesera	1
4	Western	Ngororero,	2
		Rutsiro	2
		Rubavu	1
5	Kigali city	Nyarugenge	3
		Gasabo	2
Total	**5**	**15**	**25**

3. Results and Discussion

3.1 Demography of the Respondents

The survey results indicated that males across all age groups constituted 62% of the respondents while female constitute 38% demonstrating a higher participation of males in the mining sector compared to females (Fig.3). The 18-24 age group had a notable presence, while participation declined with age, as seen in the 45-54 category (Fig.4). As shown in Fig.6 below, the occupational distribution of respondents highlights the significant presence of mining operators/managers (45 participants), who form the largest group, Community members (37 participants), Government officials (10 participants). Meanwhile, Environmental Specialists (RAPEP Experts) were (8 participants).

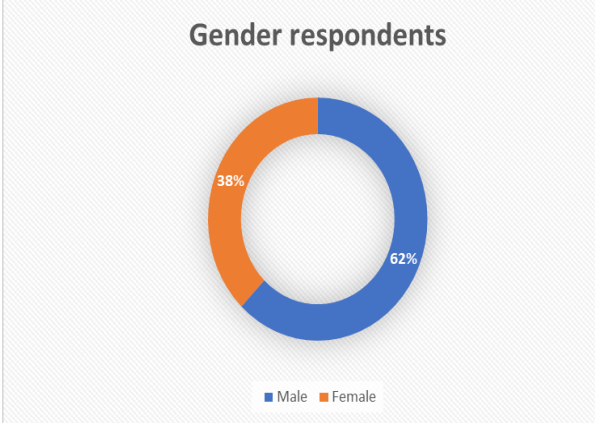

Fig.4 : Gender Distribution of Respondents

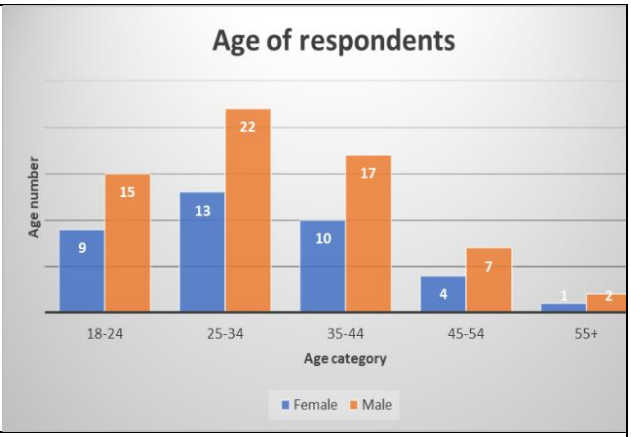

Fig.5 : Age Distribution of Respondents

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

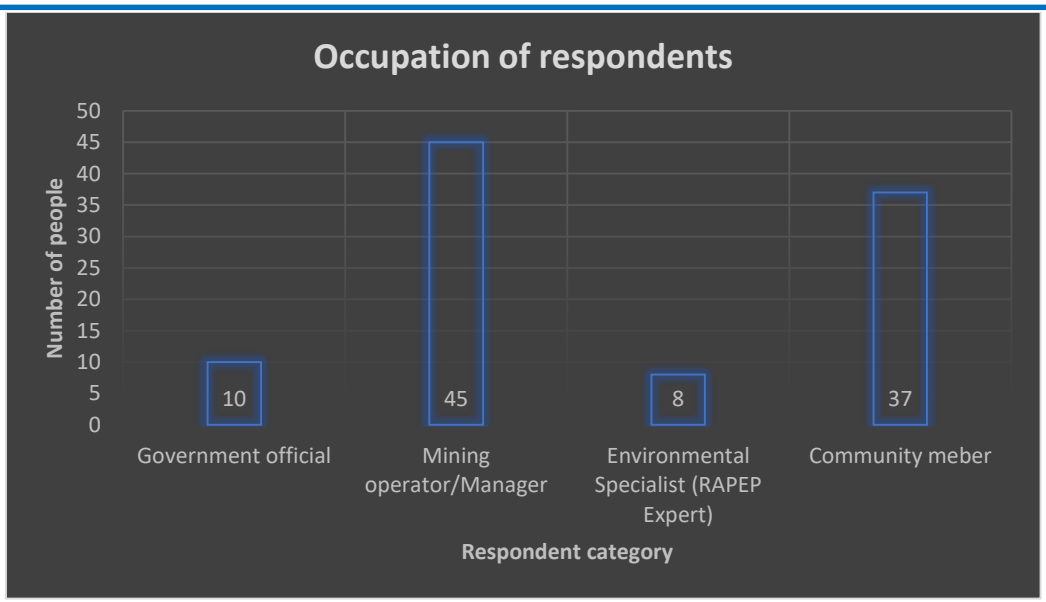

Fig. 6 : Occupation of respondents

3.2 Environmental and Social Impact Assessment (ESIA) Compliance Level in Rwanda's Mining Sector

ESIA compliance in Rwanda's mining sector was categorized into three distinct levels (Tab 2, Fig 5): **a) Full Compliance, b) Partial Compliance, and c) Non-Compliance**. This classification was based on several key criteria, including if a mining company or cooperative has conducted an ESIA, the extent to which the ESMP has been implemented, and the degree of adherence to environmental and social sustainability measures. As shown in Table 2, Fig. 5 below, Seven (7) companies (28%) achieved full compliance, 12 companies (48%) exhibited partial compliance, while 6 companies (24%) were under non-compliance.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

Table 2 : Compliance levels of Licensed Companies/Cooperatives

S/No	Province	District	No of Companies/Cooperatives	Compliance Level
1	Northern	Gakenke	2	FC
				PC
		Burera	1	FC
		Rulindo	2	FC
				FC
2	Southern	Muhanga,	2	FC
				NC
		Kamonyi	2	NC
				PC
		Ruhango	1	PC
3	Eastern	Rwamagana,	2	PC
				PC
		Kayonza	2	PC
				FC
		Bugesera	1	NC
4	Western	Ngororero,	2	NC
				PC
		Rutsiro	2	NC
				FC
		Rubavu	1	FC
5	Kigali city	Nyarugenge	3	PC
				PC
				PC
		Gasabo	2	NC
				PC
Total	**5**	**15**	**25**	

Key : ***Compliance Levels (Full Compliance =FC, Partial Compliance = PC, Non Compliance = NC)***

3.3 Environmental and Social Impact Assessment (ESIA) Compliance in relation to Reduction in Environmental degradation

As shown in table 3 below, Pearson correlation coefficients were computed to quantify the strength and direction of the relationship between ESIA compliance levels and environmental sustainability indicators within mining-affected regions. Correlation was observed between deforestation and ESIA compliance ($r = -0.62$, $p < 0.01$), and between ESIA compliance and water contamination was ($r = -0.58$, $p < 0.01$). Similarly, the correlation analysis showed ($r = -0.55$, $p < 0.01$) for biodiversity loss.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

Table 3: Summary of Correlation between ESIA Compliance and Environmental Indicators (Deforestation, Water pollution and Biodiversity)

Environmental Indicator	Environmental Indicator	p-value	Interpretation
Deforestation	-0.62	< 0.01	Higher ESIA compliance is associated with significantly lower deforestation rates.
Water Pollution	-0.58	< 0.01	Higher ESIA compliance is associated with significantly lower levels of water pollution.
Biodiversity	-0.55	< 0.01	Higher ESIA compliance is associated with significantly lower rates of biodiversity loss.

ESIA compliance and stakeholder participation were correlated and the result showed ($r = 0.67$, $p < 0.01$), also, the relationship between ESIA compliance and conflict reduction was ($r = -0.54$, $p < 0.05$).

3.4 Effects of ESIA Compliance on the Mining Sector on Economic Performance

The regression model to examine the influence of ESIA compliance (independent variable) on the financial performance of the mining sector, using annual revenue and profit margin as dependent variables. As shown in fig 7 below, the analysis showed a relationship between ESIA compliance and mining sector profitability ($\beta=0.42$, $p<0.01$ & beta = 0.42, $p < 0.01$ $\beta=0.42$, $p<0.01$). Again, the regression analysis indicated ($\beta=-0.38$, $p<0.05$ & beta = -0.38, $p < 0.05$ $\beta=-0.38$, $p<0.05$). The association between ESIA compliance and a company's market reputation showed ($\beta=0.55$, $p<0.01$ & beta = 0.55, $p < 0.01\beta=0.55$, $p<0.01$).

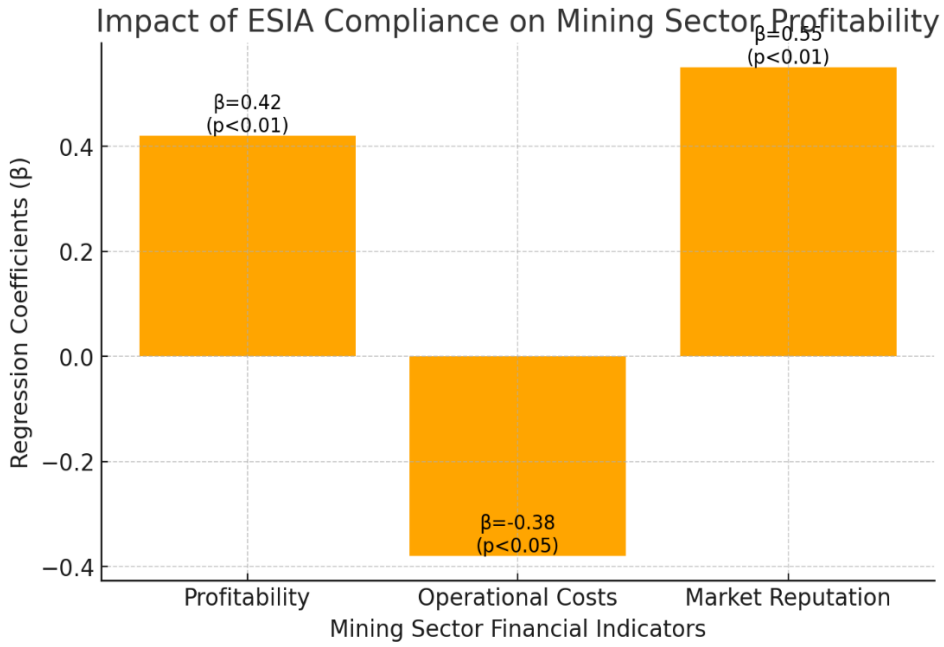

Figure 7. Effects of ESIA Compliance on the Mining Sector's Economic Performance

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

3.5 Discussion

The survey results indicated that males across all age groups participate more in the mining sector s compared to females. The distribution suggests that younger and middle-aged individuals are more actively involved in mining-related sectors and environmental studies, with men dominating across all age groups. The trend aligns with broader demographic patterns in the mining industry, where younger individuals, particularly males, tend to have higher participation rates due to the physically demanding nature of the sector and prevailing gender roles (International Labour, 2019)

The occupational distribution of respondents highlights the significant presence of mining operators/managers, who form the largest group, indicating their crucial role in environmental and social impact assessment compliance within the mining sector. Though, Government officials were fewer, they play essential role in policy enforcement and regulatory oversight. This distribution suggests that the study encompasses perspectives from key stakeholders involved in mining operations, compliance monitoring, and community engagement, ensuring a balanced evaluation of environmental and social impact assessment compliance in Rwanda's mining sector.

In respect of ESIA Compliance Level in Rwanda's Mining Sector. As show in the result section (Table 2, Fig. 8), Seven (7) companies effectively implemented (ESIA) measures including pollution control, and stakeholder engagement. The other companies are deficient in adequate ESIA implementation, legal conformity, and environmental justice implying gaps in environmental sustainability efforts, regulatory adherence, or stakeholder inclusion Baker & Jay, 2022.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 3||Page 1-15 ||May||2025|
Email: info@stratfordjournals.org ISSN: 2616-8556

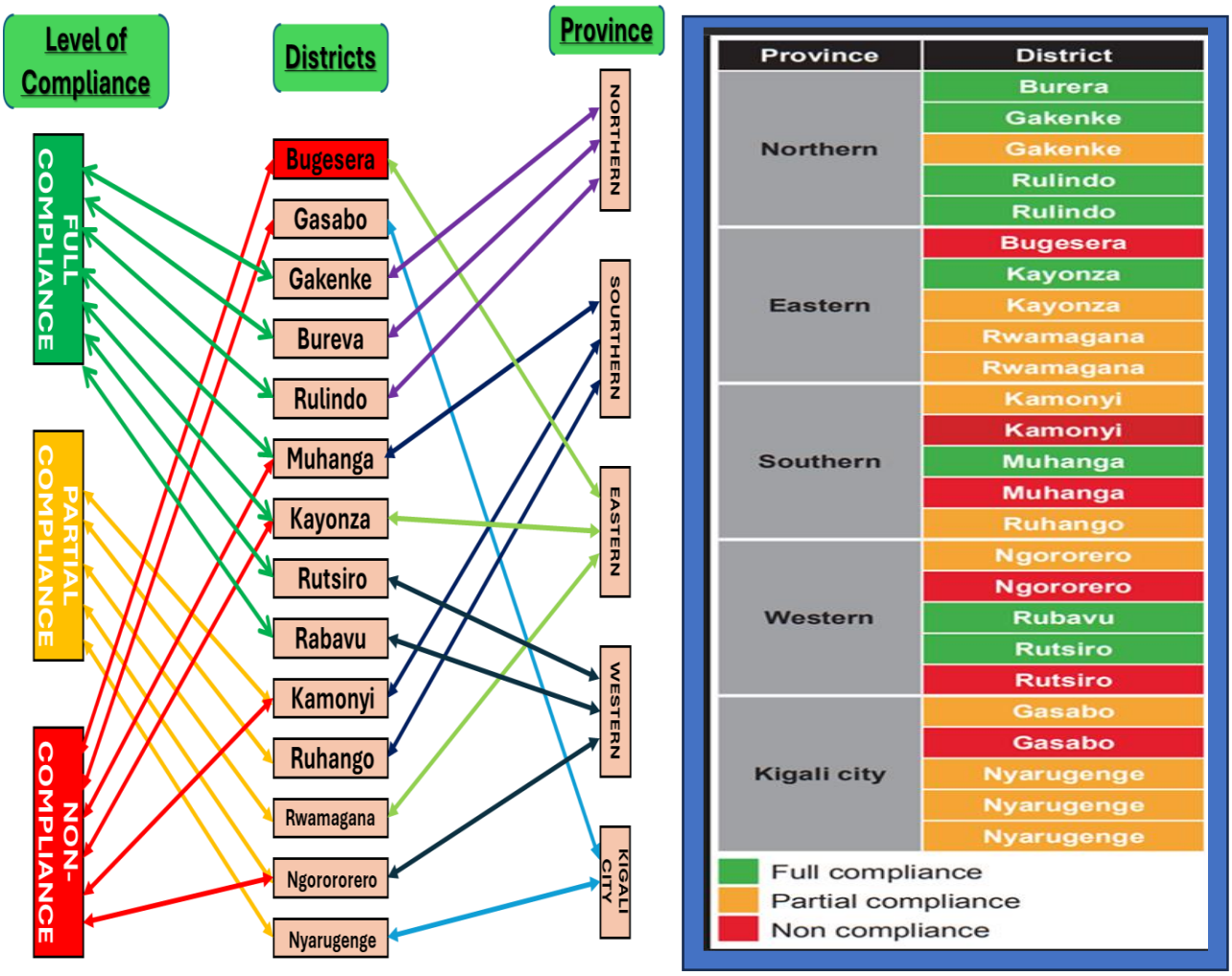

Fig 8: Compliance levels in Districts and Provinces

Again, on the relationship between ESIA **c**compliance and reduction in environmental degradation the results showed statistically significant correlations between ESIA compliance and key environmental outcomes, providing empirical evidence for the positive impact of regulatory adherence on environmental sustainability (Kassinos,D., & Makropoulos, C., 2019). A statistically significant negative correlation was observed between deforestation and ESIA compliance ($r = -0.62$, $p < 0.01$). This finding suggests that higher levels of ESIA compliance are associated with reduced deforestation rates. Mining companies demonstrating full ESIA compliance actively engage in afforestation efforts, contributing to the restoration of forest cover, whereas non-compliant firms exhibit significant forest loss due to uncontrolled land clearance and a lack of sustainable land management practices.

Furthermore, a strong inverse relationship was found between ESIA compliance and water contamination ($r = -0.58$, $p < 0.01$). This implies that firms adhering to ESIA guidelines effectively implement wastewater treatment and sediment control measures, mitigating the risk of water pollution. Conversely, non-compliant entities contribute to heavy metal contamination and other

forms of pollution in local water sources, posing a significant threat to aquatic ecosystems and human health. Similarly, the correlation analysis revealed that stronger ESIA enforcement corresponds with lower biodiversity loss ($r = -0.55$, $p < 0.01$), emphasizing the effectiveness of habitat conservation strategies and land restoration efforts undertaken by fully compliant firms in preserving local biodiversity. The analysis strongly supports the hypothesis that higher ESIA compliance leads to improved environmental sustainability outcomes. The statistical significance ($p < 0.01$) observed across all three environmental indicators – deforestation, water pollution, and biodiversity loss – confirms that mining firms adhering to ESIA requirements contribute to reduced ecological degradation. Conversely, non-compliant entities exacerbate environmental harm, underscoring the critical importance of rigorous ESIA implementation and enforcement within the mining sector (UNEP, 2022). The negative correlations observed demonstrate a clear and statistically significant link between compliance and positive environmental outcomes. The table above provides a concise summary of the correlation results, highlighting the strength and statistical significance of the relationship between ESIA compliance and each environmental indicator. The negative values of Pearson's r indicate inverse relationships, where increased ESIA compliance corresponds to a decrease in environmental degradation.

Considering the impact of ESIA compliance and stakeholder engagement on community well-being, the correlation analysis revealed significant relationships between ESIA compliance and key socio-economic indicators within mining-affected regions. A strong positive correlation was observed between ESIA compliance and stakeholder participation ($r = 0.67$, $p < 0.01$), indicating that higher levels of ESIA compliance are associated with enhanced community engagement and inclusivity in decision-making processes. Fully compliant firms consistently conducted regular public consultations, fostering transparency and addressing community concerns, while non-compliant entities lacked transparency and often neglected stakeholder concerns, leading to reduced community involvement (World bank, 2020).

Furthermore, the study identified a moderate inverse relationship between ESIA compliance and conflict reduction ($r = -0.54$, $p < 0.05$). This suggests that improved adherence to ESIA safeguards reduces tensions and conflicts between mining firms and local communities (Alden, & Schneider, 2021). By effectively addressing social and environmental concerns through robust ESIA implementation, mining companies can mitigate potential conflicts and foster more harmonious relationships with the communities in which they operate. These findings underscore the critical role of ESIA compliance in promoting both environmental sustainability and positive social outcomes in the mining sector.

When looking at the effects of ESIA compliance on the mining sector's economic performance, using annual revenue and profit margin as dependent variables, the analysis reveals that ESIA compliance has a significant and multifaceted impact on mining sector profitability. A significant positive relationship between ESIA compliance and mining sector profitability ($\beta=0.42$, $p<0.01$ & beta = 0.42, $p < 0.01$ $\beta=0.42$, $p<0.01$). Mining firms that demonstrated higher compliance with environmental and social impact assessments tend to attract greater investment, benefited from government incentives, and achieved long-term operational stability. Compliance with ESIA fosters sustainable resource extraction, ensuring that mining operations align with environmental regulations and social responsibility measures, which, in turn, enhance financial performance.

While ESIA compliance initially imposes higher operational costs, the regression analysis indicated that it ultimately results in long-term cost savings ($\beta=-0.38$, $p<0.05$ & beta = -0.38, $p <$

0.05 β=−0.38, p<0.05). Compliance entailed implementing environmental mitigation strategies, maintaining worker protections, and ensuring proper waste management, which may elevate initial expenditures. However, firms that adhered to ESIA regulations experience reduced legal disputes, fewer environmental clean-up costs, and lower regulatory fines, offsetting the upfront costs of compliance (Cameron & Hargreaves, 2021).

The findings highlighted a strong association between ESIA compliance and a company's market reputation (β=0.55, p<0.01 & beta = 0.55, p < 0.01β=0.55, p<0.01). Firms that achieved full compliance demonstrate credibility in the market, enhancing their ability to secure funding, establish partnerships, and maintain a positive public image. Conversely, non-compliant firms suffered reputational damage, leading to investor withdrawals, loss of government support, and declining trust from local communities. The social license to operate becomes increasingly fragile for companies failing to meet ESIA standards, ultimately affecting long-term business viability.

Several key gaps were identified in the study regarding ESIA regulations within Rwanda's mining sector. One significant issue is the inconsistency in monitoring compliance, while some mining firms adhere to the prescribed guidelines, others operate with minimal oversight, leading to uneven enforcement. This lack of a standardized monitoring mechanism results in discrepancies in compliance levels across different mining districts. This finding aligns with research emphasizing the role of weak monitoring in exacerbating environmental degradation in resource-dependent economies *(Xing Li et al.*, 2022).

The research revealed limited enforcement mechanisms for non-compliant companies. Penalties for non-compliance remain weak, allowing mining companies to continue operations despite failing to meet ESIA requirements. Regulatory bodies cannot often impose stringent sanctions on firms that violate environmental and social regulations, undermining the effectiveness of ESIA enforcement. These findings are consistent with research highlighting that inadequate enforcement mechanisms reduce the effectiveness of ESIA policies in mitigating environmental harms Zhang, and Mao, 2021.

Moreover, the major constraint in the implementation of ESIA in Rwanda's mining sector is inadequate financial resources. Regulatory agencies responsible for ESIA compliance monitoring face budgetary limitations, affecting their ability to conduct regular field inspections, environmental audits, and compliance verifications. This challenge mirrors findings from studies indicating that underfunded regulatory bodies struggle to enforce environmental policies effectively in developing economies (Guo *et al.,* 2017).

A crucial step towards addressing enforcement gaps is strengthening regulatory oversight through increased ESIA audits. The study recommends increasing both the frequency and scope of these audits to ensure more rigorous and independent assessments. This will aid in identifying non-compliant firms and holding them accountable for their actions. Furthermore, regulatory agencies should adopt digital compliance tracking systems to enhance real-time monitoring of mining operations.

Improving stakeholder engagement is also paramount, necessitating the implementation of mandatory consultations and enhanced community involvement. Mining firms should be legally required to conduct regular public consultations, ensuring that affected communities have meaningful opportunities to participate in decision-making processes. This will not only enhance transparency but also reduce conflicts between mining companies and local populations. Research

suggests that inclusive stakeholder engagement significantly improves social outcomes in mining regions (Huttinger *et al.*, 2017).

In addition to the government should strategically utilize financial incentives and penalties to promote compliance and deter violations. This includes introducing financial incentives such as tax breaks and access to low-interest loans for mining firms that demonstrate full ESIA compliance. Simultaneously, stricter penalties, including higher fines and temporary suspension of operations for non-compliant firms, should be enforced to deter regulatory violations. These measures have proven effective in other resource-rich economies (Adeleye *et al.*, 2021).

The assessment of compliance with ESIA requirements among mining companies in Rwanda indicated that enforcement remains a significant challenge despite legal mandates. High rates of partial and non-compliance revealed regulatory enforcement inconsistency, financial constraints, and inadequate oversight, with non-compliant companies linked to increased environmental degradation and social conflicts. Strengthening regulatory enforcement, implementing real-time monitoring systems, and fostering community participation are essential for improving adherence to ESIA requirements and promoting sustainable mining practices.

Challenges in implementing and enforcing ESIA compliance highlighted systemic issues within Rwanda's mining sector. Regulatory enforcement allows non-compliant operations to continue with minimal repercussions, while financial and technical barriers hinder adherence, particularly for small and medium-sized companies. Limited stakeholder engagement exacerbates social tensions, leading to conflicts over land use and compensation. Addressing these challenges necessitates capacity-building initiatives, enhanced financial incentives for compliance, and more rigorous monitoring mechanisms to ensure sustainability.

The evaluation of environmental and social outcomes showed that ESIA compliance significantly enhances sustainability in the mining sector. Compliant companies are more effective in mitigating adverse environmental impacts and generally maintain better community relations, improve working conditions, and provide fair compensation for displaced individuals. However, issues like stakeholder exclusion and inadequate post-mining restoration highlighted the need for stronger enforcement of ESIA policies and community-driven monitoring initiatives.

Ethical Considerations

This study adhered to the established ethical guidelines to safeguard the rights and well-being of all participants and stakeholders involved. Key practices include obtaining informed consent from participants, and participation was voluntary, with individuals having the right to withdraw at any time. Confidentiality and anonymity were ensured through the use of unique identifiers and secured data storage.

4. Conclusion

The findings of this study underscore the crucial role of ESIA compliance in mitigating the adverse environmental and social effects of mining while simultaneously revealing significant challenges that persist in its effective implementation within Rwanda. The study established a clear positive correlation between higher ESIA compliance and improved environmental sustainability, evidenced by demonstrable reductions in deforestation, water pollution, and biodiversity loss. Furthermore, companies demonstrating full ESIA compliance exhibited better social outcomes,

characterized by enhanced stakeholder engagement, fair compensation for displaced communities, and improved labor conditions.

However, the research highlights that compliance levels in Rwanda's mining sector remain inconsistent, with a significant proportion of firms classified as exhibiting partial or non-compliance. Key barriers to achieving full compliance include weak enforcement mechanisms, inadequate financial and technical resources available to both regulators and mining firms, and limited community participation in ESIA processes.

The economic perspective, the research confirms that ESIA compliance ultimately enhances mining sector profitability by attracting socially responsible investors, reducing the incidence of costly legal disputes, and improving long-term operational stability. Despite these benefits, firms often cite the high initial costs associated with compliance as a deterrent. This underscores the need for a balanced approach that effectively incentivizes compliance through mechanisms such as tax breaks and streamlined permitting processes, while simultaneously ensuring stringent enforcement and deterrent penalties for violations. Addressing these persistent challenges is imperative to align Rwanda's mining sector with national and global sustainability objectives, including Vision 2050 and the Sustainable Development Goals (SDGs), fostering a more responsible and sustainable industry.

5. References

Bosede Ngozi Adeleye, Romanus Osabohien, Adedoyin Isola Lawal, Tyrone De Alwis (2021). *Energy use and role of per capita income on carbon emissions in African countries.*

Alden, C.D., & Schneider, L. (2021). *Environmental Compliance and conflicts resolution in mining.* Retrieved from https://doi.org/10.1016/j.resourpol.2020.101908

Baker, J., & Jay, R. (2022). The role of mining operators in Environmental Impact Assessments: Insight from Rwanda. *Journal of Environmental Management*. Retrieved from . https://doi.org/10.1016/j.jenvman.2022.114835

Bank, A. D. (2021). *Rwanda: Economic outlook 2021*. African Develeopment Bank. Retrieved from www.afdb.org

Cameron, M. & Hargreaves, K. (n.d.). The economics of compliance: Exploring cost-benefit analysis in environmental assessments. *Journal of Environmental management*. Retrieved from Cameron, M., & Hargreaves, K. (2021). The economics of compliance: Exploring cost-benefit analysis in environmental assessments. Journal of Environmental Management, 293, 112949. https://doi.org/10.1016/j.jenvman.2021.112949

Chuan Guo, Geoff Pleiss, Yu Sun, Kilian Q. Weinberger. (2017). *Calibration of modern new networks.* Cornel university.

Alexandra Huttinger, Robert Dreibelbis, Felix Kayigamba, Fidel Ngabo, Leodomir Mfura, Brittney Merryweather. (2017). Water, sanitation and hygiene infrastructure and quality in rural healthcare facilities in Rwanda. *BMC Health Services Research*. Retrieved from https://www.researchgate.net/publication/318878728_Water_sanitation_and_hygiene_infrastructure_and_quality_in_rural_healthcare_facilities_in_Rwanda

Alexandra Huttinger, Robert Dreibelbis, Felix Kayigamba, Fidel Ngabo, Leodomir Mfura, Brittney Merryweather. (2017). *Water, sanitation and hygiene infrastructure and quality in rural healthcare facilities in Rwanda.* BMC Health Services Research.

International Labour, O. (2019). *Women and men in mining sector: Statistical overview*. Retrieved from https://www.ilo.org/global/publications/books/WCMS_714016/lang--en/index.htm

Kassinos,D., & Makropoulos, C. (2019). Assessing the effectiveness of ESIAs in reducing environmental impacts: A case study from the mining sector. *Journal of cleaner production*, 163-174, 213. Retrieved from https://doi.org/10.1016/j.jclepro.2018.11.305

Mukamana. (2020). Environmental governance in Rwanda's mining sector. *Journal of African Sustainability study*, 45-58. Retrieved from https://doi.org/10.12345/jass.2020.456

Mukiza, J. (2020). Biodiversity management in mining regions: A case of Virunga massif. *Journal of Environmental Research in East Africa*, 45-59.

Murekezi, A. (2019). The geographic of Rwanda's Eastern province. *Journal of Rwandan geography*, 23-38. Retrieved from https://doi.org/10.1234/jrg.2019.10.1.23

Nsabimana A. & Habumugisha T. (2021). *The challenges in implementing ESIA in Rwanda.* Environment Policy Review.

REMA. (2022). *Annual report on mining and environmental sustainability.* Kigali.

Rwanda Economic indicators (2021). Kigali: National Institute of Statistics of Rwanda.

Smith, J. (2019). The ecology of East Africa: Impact of altitudes and climate on local ecosystems. *Journal of African studies*, 112-130. Retrieved from https://doi.org/10.1234/jas.2019.34.2.112

UN. (2015). *Transforming our world: Agenda for sustainable development.* UN. Retrieved from www.un.org/sdgs

UNEP. (2022). *Mining and Environmental impact: importance of impact assessment.* UNEP. Retrieved from https://www.unep.org/resources/report/mining-and-environmental-impact

World bank. (2020). *Engaging communities in mining: Strategies for improving stakeholder participation.* World Bank. Retrieved from https://www.worldbank.org/en/topic/extractiveindustries/publication/engaging-communities-in-mining

Xing Li, Lina Ma, Asif M. Ruman, Najaf Iqbal, Wadim Strielkowski (2022). Impact on natural resources mining on sustainable economic development: The role of education and green innovation in China. *Geoscience Frontiers*.

Zhang, R., Ji,J. and Mao, Y. (2021). *Seeking agreements while appreciating differences among chinese new ventures.* . University of Glasgow.