Journal Homepage: www.ijarpr.com ISSN: 3049-0103 (Online)

International Journal of Advance Research Publication and Reviews

Vol 03, Issue 11, pp 43-48, November, 2026

# Effectiveness of Environmental Impact Assessment in Managing the Environmental Impacts of Mining and Quarrying: Evidence from the Mageragere Mining Zone, Rwanda

*Aurore UMUHOZA[1*], Christophe MUPENZI[1]*

[1] Faculty of Environmental Studies, University of Lay Adventists of Kigali (UNILAK), Kigali, Rwanda
*Corresponding author: umuhoza130@gmail.com

**ABSTRACT :**

Environmental Impact Assessment (EIA) is a mandatory licensing requirement for mining and quarrying in Rwanda, yet environmental degradation persists in intensively exploited areas. This study assessed how effectively EIA manages the environmental impacts of mining and quarrying in the Mageragere Mining Zone, Nyarugenge District, Kigali. A mixed-methods design combined a household survey (n = 150) across the seven cells of the sector, semi-structured interviews with 15 mining and quarry operators and 5 technical staff of regulatory agencies, field observation, review of licensing data, and Landsat-based Land Use and Land Cover (LULC) change detection for 2017, 2020 and 2025. Seventeen licensed operations occupy about 962 ha, roughly 17.6% of the sector. Among the 140 respondents who answered the trend question, 112 (80%) reported that extraction had increased near their homes over five years. Respondents identified soil erosion and landscape degradation (38%), barren soil (30%), loss of vegetation cover (14%) and deforestation (10%) as the main problems. Forest cover fell from 2,813.6 ha (51.5% of the sector) in 2017 to 863.8 ha (15.8%) in 2025, while bare land rose by 474 ha and built-up land by 671.8 ha. Only 8% of residents considered mining well regulated, and all 15 operators acknowledged a gap between EIA commitments and field practice, citing steep terrain, low priority given to the EIA report, falling mineral prices and weak inspection. EIA provides a sound design framework in Mageragere, but its effectiveness is constrained by post-approval monitoring, enforcement and capacity gaps. Specialised EIA-oriented inspections, additional regulatory staff, independent environmental audits, progressive rehabilitation and community awareness are recommended.

***Keywords:*** *Environmental Impact Assessment; mining; quarrying; land degradation; land use and land cover; environmental compliance; Rwanda*

## 1. INTRODUCTION

Environmental protection and economic development are often treated as competing objectives, which makes sustainable development difficult to achieve in sectors that depend on natural resource extraction. Environmental Impact Assessment (EIA) was developed to reconcile the two by integrating environmental considerations into decision-making before projects are approved. It is commonly defined as the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals before major decisions are taken and commitments made (Glasson et al., 2012). Since its formal introduction under the United States National Environmental Policy Act of 1969, EIA has been adopted in more than a hundred countries, and in many African states it became a legal requirement during the 1980s and 1990s.

Mining and quarrying are among the activities for which EIA is mandatory because of their potential for land degradation, deforestation, soil erosion, water contamination, air pollution and landscape destruction (Byizigiro et al., 2020). In Rwanda, the EIA system rests on the creation of the Rwanda Environment Management Authority (REMA) and was later strengthened through environmental and mining legislation (Nkundabose et al., 2020; Republic of Rwanda, 2018a, 2018b). Mining and quarrying proponents must obtain EIA approval before licensing, implement an approved Environmental Management Plan (EMP), and comply with monitoring and mitigation requirements throughout operation.

Despite these requirements, visible degradation continues in mining areas. Studies in comparable settings attribute this to weak enforcement, limited post-approval monitoring, insufficient stakeholder participation and inadequate institutional capacity, which together open a gap between the impacts predicted in EIA reports and conditions on the ground (Byizigiro et al., 2020; Sharma & Hategekimana, 2018). Existing Rwandan studies have examined the legal framework, EIA in infrastructure projects, or the general impacts of artisanal and small-scale mining, but empirical evidence on EIA effectiveness at the level of a specific mining zone is scarce.

The Mageragere Mining Zone in Nyarugenge District, about 8–10 km from Kigali city centre, supplies stone, aggregates and 3T minerals (tin, tantalum and tungsten) to the capital's construction boom and is a clear case in which to test whether EIA delivers on its promise. This study therefore (i) describes the implementation of EIA in mining and quarrying projects in the zone, (ii) analyses the major environmental impacts of these activities, and (iii) examines how effectively EIA manages those impacts.

## 2. THEORETICAL AND CONCEPTUAL BASIS

The study draws on three perspectives. Sustainable Development Theory treats EIA as an operational tool for balancing mineral extraction with long-term environmental and social well-being. Environmental Management Theory emphasises preventive planning, monitoring and control, with EMPs as the instruments that translate EIA recommendations into practice. Institutional Theory explains why legally sound EIA systems may still underperform: organisational behaviour is shaped by regulatory, normative and cognitive pressures, so weak enforcement, poor inter-agency coordination and limited capacity allow operators to comply at the approval stage while follow-up remains thin.

Conceptually, EIA (screening, scoping, report preparation, public consultation, approval, EMP implementation, monitoring and enforcement) is treated as the independent variable, and the environmental outcomes of mining and quarrying (land degradation, soil erosion, vegetation loss, dust and noise, sedimentation and abandoned pits) as the dependent variable. The relationship is moderated by monitoring and inspection, compliance, operator awareness and technical capacity, and stakeholder involvement. Where these factors are strong, EIA is expected to reduce impacts; where they are weak, a gap emerges between approved mitigation and actual conditions.

## 3. MATERIALS AND METHODS

### *3.1 Study area*

Mageragere Sector lies in the west of Kigali City and covers 54.65 km² (5,465 ha) in seven cells: Kavumu, Mataba, Ntungamo, Nyarufunzo, Nyarurenzi, Runzenze and Kankuba. It had an estimated population of 59,747 (NISR, 2023). The sector occupies the eastern slopes of the Congo–Nile Ridge at 1,400–1,900 m above sea level, with steep hillsides, rocky outcrops and narrow valleys over granite, schist and lateritic formations. Seventeen licensed operations were active: three mining companies working four mining sites (large-, medium- and small-scale), four industrial quarries and ten commercial small-scale quarries.

### *3.2 Research design and data collection*

A mixed-methods design was used (Creswell, 2014). Secondary data came from EIA reports and EMPs of operators, inspection reports, policy and legal documents, and licensing data from the Rwanda Mines, Petroleum and Gas Board (RMB), REMA and the Rwanda Development Board. Primary data were gathered in March 2026 through four techniques. First, a structured household questionnaire covered personal data, proximity and trends in mining activity, regulation and compliance, observed impacts, and proposed remedial actions. Second, 20 key informants were interviewed with semi-structured guides: 15 mining and quarry operators and 5 technical staff of lead regulatory agencies. Third, field observations at mining and quarry sites used standard checklists, geographic coordinates and photographs to document erosion, exposed surfaces, unstable slopes, unrehabilitated pits and vegetation loss. Fourth, LULC change was derived from Landsat imagery.

### *3.3 Sampling*

Household sample size was determined with Yamane's formula at a margin of error of about 8%, giving 150 households, allocated to the seven cells in proportion to their share of the population and selected by simple random sampling, with priority to areas close to extraction sites. The response rate was 100%. Operators and regulatory officials were selected purposively for their technical knowledge of EIA implementation.

### *3.4 Data analysis*

Survey data were analysed with Microsoft Excel and SPSS to generate frequencies, percentages and tables. Interview, observation and document data were analysed thematically. For spatial analysis, Landsat images for 2017, 2020 and 2025 were pre-processed (geometric correction, clipping, enhancement) and classified with a supervised approach into forest, cropland, built-up, water, bare land and rangeland. Accuracy was assessed with ground-truth data, and post-classification change detection was used to quantify the area change of each class. Validity was strengthened by triangulating surveys, interviews, observations and documents, and by expert validation from local authorities and environmental specialists. Permission was obtained from the City of Kigali and local authorities, participation was voluntary and informed, and responses were kept anonymous.

## 4. RESULTS

### *4.1 Respondent profile*

Of the 150 household respondents, 63.3% were male and 36.7% female. Most (53.3%) were aged 26–45 years, 72% had primary or secondary education, and 46.7% had lived in the sector for more than ten years. Overall, 65.3% lived near extraction sites, 14.7% worked for mining companies, and 20% both lived nearby and worked in mining, so nearly all had direct exposure to the activities assessed (Table 1).

**Table 1. Profile of household respondents (n = 150)**

| Characteristic | Frequency | % |
|---|---|---|
| Male | 95 | 63.3 |
| Female | 55 | 36.7 |
| Aged 26–45 years | 80 | 53.3 |
| Primary or secondary education | 108 | 72.0 |
| Resident for more than 10 years | 70 | 46.7 |
| Live near mining/quarry sites | 98 | 65.3 |

| Characteristic | Frequency | % |
|---|---|---|
| Work for mining companies | 22 | 14.7 |
| Live nearby and work in mining | 30 | 20.0 |

*Source: Field survey, March 2026.*

***4.2 Implementation of EIA and extent of extraction***

The 17 licensed operations occupy about 962 ha, equal to roughly 17.6% of the sector (Table 2). Calliane Mines (large-scale, wolfram, 400 ha), GMDC (small-scale, wolfram, 250 ha) and ETMIN (medium-scale; cassiterite, coltan and wolfram, 100 ha) hold the largest areas, followed by industrial quarries of 25–100 ha and ten commercial quarries of about 1 ha each. Operations are spread across all seven cells and many are close to homes and farmland, which magnifies their footprint beyond licence boundaries.

**Table 2. Licensed mining and quarrying operations in Mageragere Sector**

| Licence category | Main commodity | Operations | Area (ha) |
|---|---|---|---|
| Large-scale mining | Wolfram | 1 | 400 |
| Medium-scale mining | Cassiterite, coltan, wolfram | 1 | 100 |
| Small-scale mining | Wolfram | 1 | 250 |
| Industrial quarries | Stone, aggregates, quartzite, sandstone | 4 | 202 |
| Commercial small-scale quarries | Building stone, clay, aggregates | 10 | 10 |
| Total | | 17 | 962 |

*Source: RMB licensing data (2026), compiled by the authors.*

Operators confirmed that EIAs and EMPs are prepared as part of licensing, but implementation is uneven. All 15 interviewed operators (100%) acknowledged a gap between what was promised in the EIA and what happens in the field. They gave four reasons: steep terrain that makes erosion control difficult; the treatment of the EIA report as a licensing formality rather than a working guide; falling international mineral prices that reduce funds available for environmental investment; and a speculative approach among some licence holders with little commitment to the sector. Operators and officials also pointed to few mine inspectors, inspectors with limited environmental training, low environmental awareness among artisanal and small-scale miners, weak enforcement, and the lack of inspections dedicated to EIA/EMP compliance, since routine inspections cover production, taxes, labour, safety and other matters together. REMA's responsible director reported a team of eight staff covering environmental monitoring for the whole district, too few to visit every mine twice a year, and said that joint inspections with RMB and the Environmental Protection Unit of the Rwanda National Police are now used to hold non-compliant operators accountable. Some companies had started reforestation and waste containment, but these efforts were small relative to the scale of disturbance.

***4.3 Perceived environmental impacts***

Respondents reported widespread effects (Table 3). Dust (78.7%) and soil erosion (73.3%) were most often cited, followed by water pollution or reduced water availability (66.7%), restricted access to farmland (63.3%) and cracks in houses from blasting vibration (46.7%). Employment opportunities, particularly for young people, were acknowledged by 60%, but negative impacts dominated perceptions. Among the 140 respondents who answered the trend question, 112 (80%) said extraction near their homes had increased in the last five years, 10 (7.2%) said it had decreased and 18 (12.8%) saw no change.

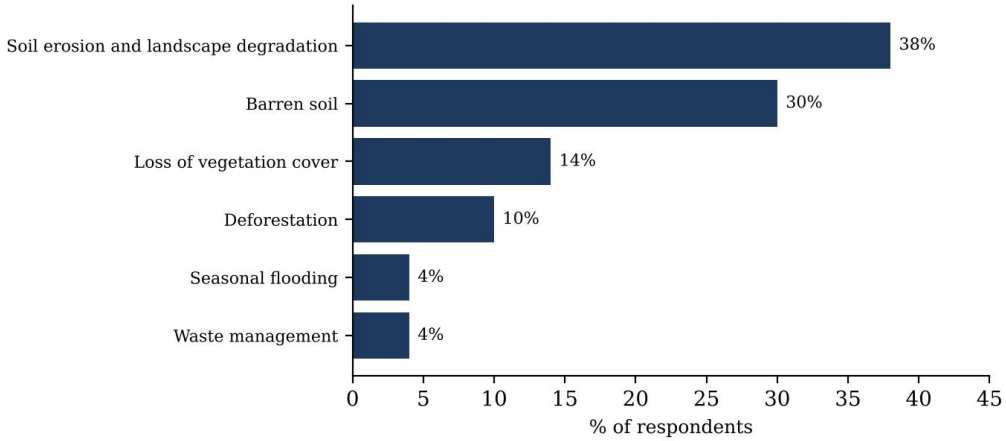
**Table 3. Effects of mining and quarrying reported by residents (n = 150, multiple responses)**

| Reported effect | Frequency | % |
|---|---|---|
| Air pollution (dust) | 118 | 78.7 |
| Soil erosion | 110 | 73.3 |
| Water pollution / reduced water availability | 100 | 66.7 |
| Restricted access to land | 95 | 63.3 |
| Employment opportunities | 90 | 60.0 |
| Vibration and structural damage | 70 | 46.7 |

*Source: Field survey, March 2026.*

When asked to name the dominant environmental challenge, 38% chose soil erosion and landscape degradation and 30% barren soil, followed by loss of vegetation cover (14%), deforestation (10%), seasonal flooding (4%) and waste management (4%) (Figure 1).

**Figure 1. Dominant environmental challenges reported by respondents**




*Source: Field survey, March 2026.*

***4.4 Land use and land cover change***

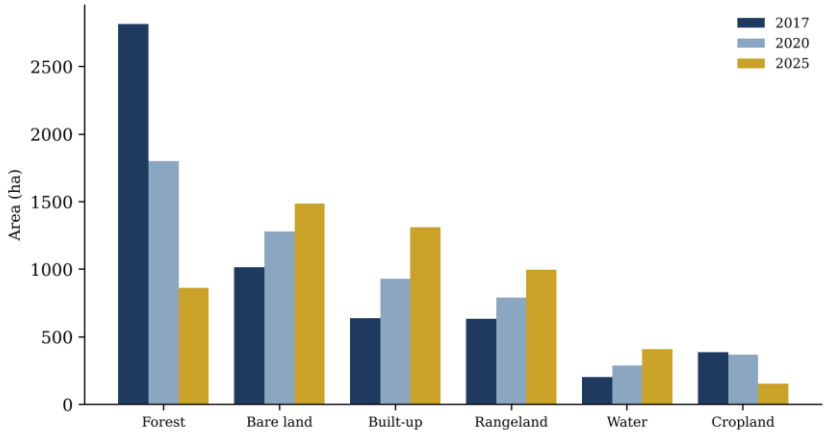
LULC analysis shows large changes between 2017 and 2025 (Table 4, Figure 2). Forest cover declined from 2,813.6 ha (51.5% of the sector) in 2017 to about 1,800 ha (33%) in 2020 and 863.8 ha (15.8%) in 2025, a loss of 1,949.8 ha, or about 69% of the 2017 forest area. Over the same period bare land expanded by 474 ha (1,015 to 1,489 ha), built-up land by 671.8 ha (637.9 to 1,309.7 ha), rangeland by 365.3 ha and water bodies by 204.7 ha, the last probably reflecting water accumulation in excavated pits and poor drainage. Cropland shrank by 234 ha, from 389.5 to 155.5 ha, a reduction of about 60%. Together these trends indicate loss of natural cover and farmland to exposed ground, settlement and degraded land, consistent with the reported pressure from extraction and the weak rehabilitation described by operators and residents.

**Table 4. Land use and land cover in Mageragere Sector, 2017–2025 (ha)**

| Class | 2017 | 2020 | 2025 | Change 2017–2025 |
|---|---|---|---|---|
| Forest | 2,813.6 | 1,800.0 | 863.8 | −1,949.8 |
| Bare land | 1,015.0 | 1,280.0 | 1,489.0 | +474.0 |
| Built-up | 637.9 | 930.0 | 1,309.7 | +671.8 |
| Rangeland | 633.0 | 790.0 | 998.3 | +365.3 |
| Water | 205.0 | 290.0 | 409.7 | +204.7 |
| Cropland | 389.5 | 370.0 | 155.5 | −234.0 |

*Source: Landsat-based classification (USGS, 2025), authors' analysis.*

**Figure 2. Land cover area by class in 2017, 2020 and 2025**




*Source: Landsat-based classification (USGS, 2025), authors' analysis.*

***4.5 Regulation, enforcement and community perspectives***

Only 8% of respondents considered mining well regulated, 28% gave a middle response, and 64% said it was not well regulated. Residents also described

limited awareness of their rights, especially around expropriation, and said that local authorities are often outweighed by the influence and financial strength of company owners, so complaints are rarely resolved quickly or fairly. About 20% of residents reported a poor understanding of their rights and responsibilities.

For remediation, 42% of respondents prioritised reforestation, 20% water treatment, 14% stricter inspection, 14% advocacy for local people, 6% awareness-raising and 4% waste management. Asked who should lead environmental management, 62% named government, 30% environmental organisations, 6% mining companies and 2% the local community. Officials proposed recognising well-performing operators with certificates or awards, EIA-only inspections, state investment in exploration so that licences go to operators prepared to invest, and a requirement that licence applicants secure land and compensate nearby residents before a licence is granted.

## 5. DISCUSSION

The findings show that EIA in Mageragere is strong on paper but weak in delivery. Mitigation measures commonly prescribed in EIAs, including topsoil conservation, drainage control, slope stabilisation, progressive rehabilitation, reforestation and waste management, directly address the impacts residents report, yet erosion, barren land and deforestation continue and are visible in the LULC record. This pattern matches the international literature, in which EIA effectiveness depends less on the quality of the report than on post-approval monitoring, enforcement and funding for mitigation (Byizigiro et al., 2020; Lottermoser, 2010; Sharma & Hategekimana, 2018).

The evidence supports an institutional explanation. A regulator with a handful of staff for a whole district, inspections that bundle environmental checks with many other duties, and operators who treat the EIA as a licensing document create exactly the conditions Institutional Theory predicts: compliance at approval and limited follow-up afterwards. Market conditions add to the problem, since low mineral prices reduce operators' willingness to fund mitigation, and the speculative holding of licences reduces long-term commitment. The community's strong preference for government leadership suggests that residents see enforcement, not voluntary action, as the missing element.

Two cautions apply. First, LULC change in a fast-urbanising peri-urban area is not caused by mining alone, so the associations reported here should be read as evidence of pressure consistent with extraction rather than as a precise attribution. Second, much of the perception evidence is self-reported; triangulation with operator and regulator interviews and with the satellite record strengthens, but does not replace, direct compliance audits of individual EMPs, which remain a task for future work.

## 6. CONCLUSION AND RECOMMENDATIONS

EIA is firmly embedded in mining and quarrying licensing in the Mageragere Mining Zone, and its design offers appropriate tools for managing the main impacts. However, its effectiveness is limited by weak post-approval monitoring, irregular inspections, limited institutional and operator capacity, insufficient funding for mitigation and low community awareness. Forest loss of more than two-thirds since 2017, expanding bare and built-up land, shrinking cropland and the widespread perception of weak regulation show a persistent gap between EIA commitments and field practice.

To the government and regulators, the study recommends: increasing staffing and technical capacity at REMA and RMB; organising inspections dedicated to EIA/EMP compliance; strengthening enforcement and sanctions; requiring independent environmental audits of small-scale operators at least twice a year to compensate for limited inspection capacity; investing in deeper mineral exploration to support long-term planning; making EIA oversight independent of investment promotion functions; and educating communities about their rights and the responsible institutions. To operators, it recommends full compliance with EIAs and EMPs, progressive rehabilitation and restoration of degraded land, cleaner and more efficient processing technologies, and continuous environmental training for staff. Future studies should compare EIA performance across mining zones, test remote sensing for routine compliance monitoring, and assess the economic and environmental trade-offs of mining development.

***ACKNOWLEDGEMENTS***

The authors thank the University of Lay Adventists of Kigali, the Rwanda Mines, Petroleum and Gas Board, the Rwanda Environment Management Authority, the City of Kigali and Mageragere Sector authorities for their support during data collection, and all survey and interview respondents.

**REFERENCES :**

- Abebe, W. B., Douven, W. J. A. M., & McCartney, M. (2007). EIA implementation and follow-up: A case study of Koga irrigation and watershed management project, Ethiopia.
- Amponsah-Tawiah, K., & Dartey-Baah, K. (2011). The mining industry in Ghana: A blessing or a curse. International Journal of Business and Social Science.
- Aragón, F. M., & Rud, J. P. (2016). Polluting industries and agricultural productivity: Evidence from mining in Ghana. Economic Journal, 126, 1980–2011. https://doi.org/10.1111/ecoj.12244
- Byizigiro, R., Biryabarema, M., & Rwanyiziri, G. (2020). Alleviating some environmental impacts resulting from artisanal and small-scale mining sector: A critical review. Rwanda Journal of Engineering, Science, Technology and Environment, 3.
- Creswell, J. W. (2014). Research design: Qualitative, quantitative and mixed methods approaches. Sage Publications.
- Glasson, J., Therivel, R., & Chadwick, A. (2012). Introduction to environmental impact assessment (4th ed.). Routledge.
- Lottermoser, B. G. (2010). Mine wastes: Characterization, treatment and environmental impacts. Springer.
- National Institute of Statistics of Rwanda (NISR). (2023). Rwanda population statistics.
- Nkundabose, J. P., Ingabire, T., Nshimiyimana, E., & Gratien. (2020). Analysis of current environmental impact assessment system in

Rwanda.

- Republic of Rwanda. (2018a). Law No. 48/2018 of 13/08/2018 on environment.
- Republic of Rwanda. (2018b). Law No. 58/2018 of 13/08/2018 governing mining and quarry operations.
- Sharma, A., & Hategekimana, C. (2018). Effectiveness of EIA in developing countries.