LatIA. 2025; 3:321
doi: 10.62486/latia2025321
ISSN: 3046-403X

REVIEW

Integrating AI to Assess Community Roles in Environmental Safeguarding During Mining: Implications for ESIA in SSA

Integrar la inteligencia artificial para evaluar el papel de las comunidades en la protección ambiental durante la minería: Implicaciones para la EIAS en África Subsahariana

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Cite as: Chavula P, Kayusi F. Integrating AI to Assess Community Roles in Environmental Safeguarding During Mining: Implications for ESIA in SSA. LatIA. 2025; 3:321. https://doi.org/10.62486/latia2025321

Submitted: 11-01-2024 **Revised:** 17-07-2024 **Accepted:** 12-05-2025 **Published:** 13-05-2025

Editor: PhD. Rubén González Vallejo

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ABSTRACT

This study investigates the role of local communities in environmental safeguarding during mining operations in Sub-Saharan Africa (SSA) and its implications for Environmental and Social Impact Assessments (ESIAs). While mining drives economic development, it often imposes environmental and social costs on local populations. The study critiques existing ESIA frameworks for privileging top-down, technocratic models that marginalize community voices. Using a systematic scoping review of 62 peer-reviewed empirical studies published since 2010, the research analyzes community participation and safeguarding practices through thematic coding and AI-powered tools like natural language processing. The findings underscore that local communities possess unique monitoring capacities, contextual knowledge, and culturally grounded environmental ethics that can enhance ESIA efficacy. These communities often respond more effectively than regulatory authorities to environmental infractions. The study also identifies structural barriers such as tokenistic participation, poverty, and policy exclusion that undermine meaningful engagement. It recommends embedding community-driven perspectives within ESIA processes by strengthening collaborative frameworks, recognizing indigenous knowledge systems, and leveraging AI to ensure inclusive and transparent evaluations. Furthermore, it argues for a shift toward participatory governance models that empower communities as co-regulators of environmental standards. By reframing ESIA as a dynamic socio-environmental negotiation, the study offers practical insights for policy reform, corporate responsibility, and sustainable development in SSA's mining sectors.

Keywords: Artificial Intelligence; Community Participation; Environmental Safeguarding; Environmental Social Impact Assessment; Mining Operations; Sub-Saharan Africa.

RESUMEN

Este estudio investiga el papel de las comunidades locales en la protección ambiental durante las operaciones mineras en África Subsahariana (ASS) y sus implicaciones para las Evaluaciones de Impacto Ambiental y Social (EIAS). Si bien la minería impulsa el desarrollo económico, a menudo impone costos ambientales y sociales significativos a las poblaciones locales. El estudio critica los marcos actuales de EIAS por privilegiar modelos tecnocráticos y verticales que marginan las voces comunitarias. A través de una revisión sistemática de 62

estudios empíricos revisados por pares publicados desde 2010, la investigación analiza la participación comunitaria y las prácticas de protección ambiental mediante codificación temática y herramientas basadas en inteligencia artificial, como el procesamiento de lenguaje natural. Los hallazgos destacan que las comunidades locales poseen capacidades únicas de monitoreo, conocimiento contextual y éticas ambientales culturalmente fundamentadas que pueden mejorar la eficacia de las EIAS. En muchos casos, estas comunidades responden de manera más eficaz que las autoridades regulatorias ante infracciones ambientales. El estudio también identifica barreras estructurales como la participación simbólica, la pobreza y la exclusión política que limitan la participación significativa. Se recomienda incorporar perspectivas comunitarias dentro de los procesos de EIAS mediante marcos colaborativos, el reconocimiento de sistemas de conocimiento indígena y el uso de inteligencia artificial para garantizar evaluaciones inclusivas y transparentes. Además, aboga por una transición hacia modelos de gobernanza participativa que empoderen a las comunidades como co-reguladoras de los estándares ambientales. Al replantear la EIAS como una negociación socioambiental dinámica, el estudio ofrece ideas prácticas para la reforma de políticas, la responsabilidad corporativa y el desarrollo sostenible en los sectores mineros de ASS.

Palabras clave: África Subsahariana; Evaluación de Impacto Ambiental y Social; Inteligencia Artificial; Operaciones Mineras; Participación Comunitaria; Protección Ambiental.

INTRODUCTION

The extractive industry, particularly mining, continues to be a cornerstone of economic development strategies across Sub-Saharan Africa (SSA), with many countries seeking to harness the wealth of natural resources such as gold, copper, diamonds, and rare earth minerals. While the sector offers promising macroeconomic gains, it also poses considerable environmental and social challenges.[1,2,3] These include land degradation, biodiversity loss, water and air pollution, as well as socio-political tensions, displacement, and inequitable access to benefits. In response, Environmental and Social Impact Assessments (ESIAs) have become standard regulatory tools intended to anticipate, mitigate, and manage such impacts.[4]

However, conventional ESIA frameworks often emphasize top-down, technocratic approaches that foreground government and corporate interests while underrepresenting the agency, knowledge, and lived experiences of local communities.[5,6,7] This omission is especially critical in SSA's rural areas, where land is not only a vital economic resource but also a cultural anchor and a source of communal identity. Local communities frequently bear the brunt of mining's externalities, yet their involvement in decision-making remains limited or tokenistic.[8]

This study explores the role of local communities in environmental safeguarding during mining operations, critically analyzing how their voices, values, and capacities are acknowledged-or marginalized—in ESIA processes. By conceptualizing ESIA as a form of social drama, the research interrogates who gets to speak, whose knowledge counts, and how community engagement is framed and operationalized in mining-related environmental governance.[5,9]

The integration of artificial intelligence (AI) offers new opportunities to enhance these evaluations. Through tools such as natural language processing (NLP), machine learning, and automated content analysis, this research examines representations of local communities within ESIA documentation and public participation records across selected Southern African case studies. AI aids in detecting narrative patterns, institutional bias, and thematic gaps—thereby strengthening transparency and inclusivity in environmental assessment processes.[9,10,11]

Furthermore, the study adopts a socio-historical and interdisciplinary lens, blending qualitative storytelling with AI-supported document analysis to examine the evolving role of communities in mining oversight. In doing so, it contributes to emerging literature that reframes ESIAs not as static regulatory exercises but as contested, culturally embedded arenas where power, knowledge, and environmental justice intersect.

This research seeks to produce actionable insights for more participatory and socially responsive ESIA practices in Sub-Saharan Africa by centering local perspectives and harnessing AI for critical discourse analysis.

METHOD

This study employed a systematic scoping review approach to explore how local communities contribute to environmental safeguarding during mining operations and the implications for Environmental Social Impact Assessments (ESIAs) in Sub-Saharan Africa (SSA). A qualitative coding methodology was used to identify key themes, community-based safeguarding practices, and ESIA-related indicators from empirical literature across multiple disciplines. The goal of this scoping review was to map the current state of knowledge and practice, develop a synthesized thematic framework, and highlight gaps relevant to policy, ESIA guidelines, and

community engagement in mining contexts.

This approach was preferred over a traditional meta-analysis due to the diversity of qualitative and context-specific insights found in environmental governance and impact assessment literature. A comprehensive literature search was conducted using three academic databases: Web of Science, Scopus, and ScienceDirect. These were selected for their breadth of peer-reviewed sources and interdisciplinary coverage of environmental studies, mining, and community engagement. The following search terms were used: ("community participation" OR "community engagement") AND ("mining" OR "extractive industry") AND ("environmental safeguarding" OR "environmental protection") ("Environmental Social Impact Assessment" OR "ESIA") AND ("local community") AND ("Sub-Saharan Africa") ("environmental governance") AND ("mining") AND ("Sub-Saharan Africa") AND ("community involvement").

Screening and Selection Process

The search focused on studies published from 2010 onwards, reflecting the growing recognition of community roles in environmental governance under evolving ESIA frameworks. All studies had to be empirical, peer-reviewed, and written in English. Exclusion criteria eliminated conceptual papers, global-scale assessments, or studies lacking evidence of community involvement in environmental safeguarding.

A total of 135 articles were screened, and after applying the inclusion and exclusion criteria, 62 papers were selected for in-depth thematic coding and analysis (see PRISMA Flow in figure 1).

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Published in 2010 or later	Published before 2010
Peer-reviewed and written in English	Not peer-reviewed or not in English
Empirical research with data on community roles in mining ESIA	Theoretical or review papers without field-based evidence
Focus on Sub-Saharan Africa	Studies outside SSA or lacking regional specificity
Discussion of local community involvement in environmental safeguarding	No mention of community role or participation in environmental processes

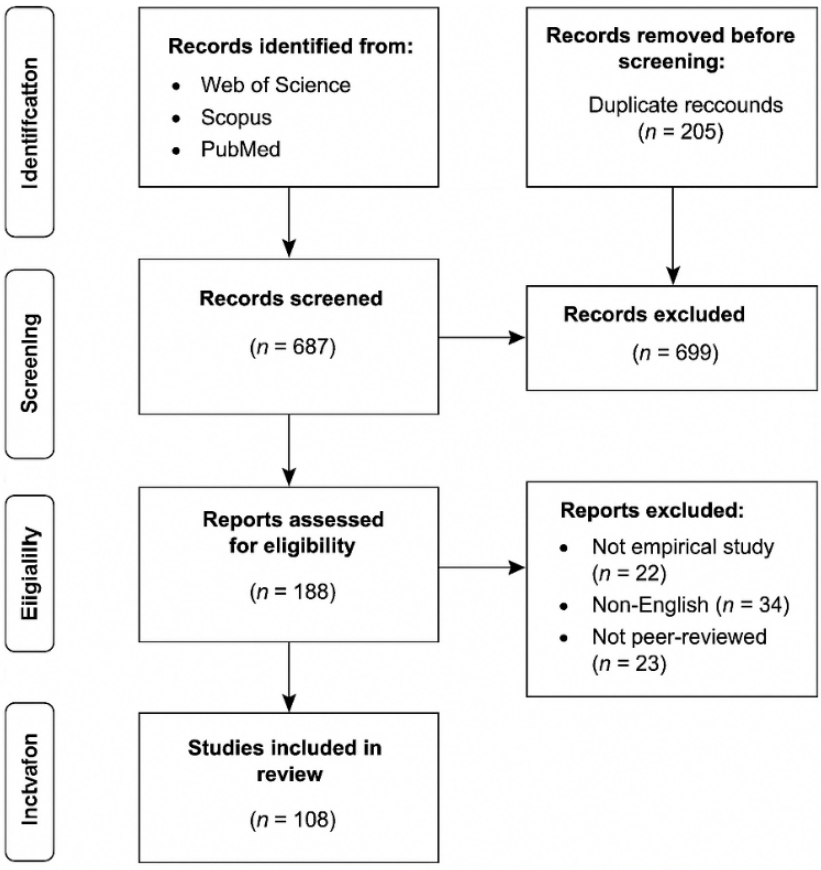

Figure 1. PRISMA Flow Diagram Adaptation for This Study

RESULTS

Local Communities and Environmental Safeguarding

Local communities in Sub-Saharan Africa (SSA) can play a significant role in protecting the environment during the lifespan of a mining project. Part of the argument and discussion presented is that through the participation of local communities, competent authorities can achieve the same, or perhaps even better and more sustainable environmental safeguarding results, compared to when these parties are solely or predominantly responsible.[5,6,7,8,9]

The capacity of local communities in SSA to safeguard the environment during the lifetime of a project will be substantiated with a review of their roles and responsibilities under international law. Local community participation in environmental assessment procedures in some countries in SSA is already well advanced through Environmental Social Impact Assessment procedures. In some countries, mining companies are also proactively supporting environmental safeguarding activities of local communities as part of their corporate social responsibility policy or social investment projects.[12]

In some countries in SSA, for example, where certain principles or performance standards are applied, mining companies are or will be required to undertake or actively support the environmental safeguarding activities of local communities. In a South African case, for example, customer-owned entities played a significant role in the environmental monitoring and management activities for a gas production project. Data from a variety of other examples will also be referred to. Although it is recognized that not all operations overseas are being run on a responsible basis and that some companies may find these findings relevant, these case studies were not limited to companies adhering to corporate social responsibility or social investment projects. The primary argument is that local communities can do positive things as the natural outcome of their position as project stakeholders or because they have been subjected to ethical or legal pressure by competent authorities, the mining company, or other responsible third parties.[7,13]

Importance of Environmental Safeguarding

There is a need for clarification of certain key terminologies and concepts that are used throughout this study. Terminologies such as local communities, mining, environmental safeguarding, and environmental social impact assessment have been used extensively in this paper, and the correct understanding and usage of these terminologies will assist in a clear and concise interpretation and comprehension to facilitate the reader's understanding of the issues under discussion.[12,13,14]

Definition and Importance of Environmental Safeguarding Environmental safeguarding, previously known as environmental management or environmental protection, concerns policies and laws about the authorization process, monitoring, reporting, and liability, or imposition of penalties in the areas related to the environment. The principles of environmental safeguarding are that the polluter should pay, that the depletion of natural resources should be minimized and that public participation in environmental decision-making should be promoted by using environmental assessment methodologies, impact prediction, and uncertainty analysis in environmental management. The objectives of the environmental safeguarding approach are to avoid, reduce, and/or offset the impacts of adverse projects on the receiving environment.[14,15]

Challenges Faced by Local Communities

For many people living near mines, their situation represents a paradox. They live in absolute poverty. Most are subsistence peasant farmers, and the basic occupational activities of this group have not changed significantly since the introduction of colonization in many of the countries of West Africa, over one hundred years ago. For a substantial number of people, such "traditional" activities are the only means of sustenance available. Yet they often live next to some of the richest individuals in the country or region with no access to this wealth.[16,17,18]

When communities argue, it is insufficient to ask these people to continue to be poor just because they use the environment in a particular way. Their lack of wealth makes it difficult to participate in alternative economic activities. Reasoning in this way identifies one of the main challenges of poor communities. It is certainly true that the activities they use to extract natural resources like wood, fish, and game might be locally sustainable, but they do not generate wealth.[15,16]

In the face of any of these challenges, it is tempting to reject the thesis. Key challenges of local communities are ignored or forgotten. Current practices of "community participation" or "consultation" are often tokenistic. The poor themselves argue that the financial resources given to organizations and formally recognized as "the community" are insufficient. The poor communities themselves are usually considered obstacles to increased efficiency by the government or the company developing the resource, and many state policies tend to concentrate wealth and land ownership in the hands of the rich.[13,17] Often, such policies appear to be intentionally designed to increase the likelihood of displacement. It is thought that simple analysis, focused on the economic activities of some people over a specified period, is usually an inefficient tool in resolving conflicts

between poor socio-economic groups. Such tools become a way of avoiding dealing with the other key issue, which provides vital clues as to whether local communities and their environment are at risk over time.[16,18]

Mining Operations and Environmental Impact

The rapid increase in mineral prices witnessed since the start of the new millennium has led to increased demand for new mineral resources. As a result, an increase in mining operations for various minerals has been witnessed around the world. China's insatiable demand for minerals—especially coal, iron ore, and copper—has affected almost all African countries. This has impacted the countries in various ways.

However, low incidences of environmental preservation and overuse due to deficiencies in environmental, moral, and social responsibility, as well as resource allocation mechanisms, account for why China's outflow of minerals should not be treated as regular international investment. This chapter aims to investigate the role of the local community in environmental safeguarding during mining operations, emphasizing the implications for the Environmental Social Impact Assessment concerning the Local Impact of Mining Activities models in the Sub-Saharan Africa context.[19,20,21]

Environmental Damage Related to Mining activity has both direct and indirect negative environmental impacts. Indirectly, from an economic point of view, natural resource misallocation is possible. Optimum use of land from a resource allocation perspective involves not only the extent of land but also the policy rules that govern the various forms that it can take. To minimize conflicts over water resource use, it is necessary to have rules for their allocation and management and acceptably inexpensive means for applying and enforcing these rules.[20]

As land has value, placing the property in the market allows savings to be made and enhances the long-term development possibilities of income for both present and future uses. Resorting to the market to give value to environmental land supplies, and information about usage costs. Surrounding water pollution, which taints and reduces water quality, is one of the most important environmental aspects that can be derived from mining, in addition to having significant undesired consequences. The possibility of mining companies and investors reaching agreements to access water could increase the revenues of the local community, which could enhance local prosperity.[20]

Types of Environmental Impact

Based on the source of the environmental impact, there are three different types of environmental impacts: those that result from the physical removal of the resource from the land – in the case of mining – known as primary impacts, and those that are caused by the subsequent current use and the future use of the production created by converting the extracted resource into the final marketable product, which includes processing, manufacturing, and transportation; those are generally known as secondary impacts. Also, there are impacts generated from the new labour income resulting from both the primary and secondary impacts which are spent on supporting and developing the local economy; those are referred to as tertiary impacts. Primary impacts relate to the extraction of the resource. In other words, primary impacts deal with the effects of mines as holes in the ground, pits on the landscape, or land consumed over time. They are local concerns because they result from local mining activity. Sets of potential impacts include local and regional land settlement, wildlife habitat disruption, water pollution, dust, noise, landscape disruptions, and air quality degradation.[22,23,24]

Local communities inevitably make use of the land and its resources for residential, agricultural, fishing, and social activities (such as hunting, gathering, and sacred activities). Therefore, local communities' social life and activities, associated with the resources of the land, are at the heart of the relationship between communities and the environment. The significance of this relationship can only be understood within the framework of the cultural, religious, and spiritual context of the local community. Nonetheless, local communities are vulnerable to environmental degradation associated with mining and its associated activities in varying degrees, depending on the economic and social structure of the communities.[4,25]

Environmental Social Impact Assessment (ESIA)

An Environmental Social Impact Assessment (ESIA) investigates the long and short-term social impacts of a proposed development on the lives of the affected people and their communities. The driving concern of an ESIA is the disclosure and mitigation of adverse issues and contrasts with the interests of those affected by the mining, which often remains focused on the adequacy of compensation payments after the event or on contributions to local development projects designed to offset the social impact costs of the operation. Mining companies have developed an impressive range of tools for analyzing environmental impacts and making predictions about outputs. In the field of social impact assessment, these tools are underdeveloped, contradictory, and often controversial. This explains why a social impact assessment is usually the most difficult and controversial component of an Environmental Impact Assessment or a Development Impact Assessment.[23,26]

The ESIA process begins with the development of a detailed baseline socioeconomic condition and

environmental inventory; second, the identification of all community groups that may experience adverse impacts or require assistance to benefit from the proposed new investment; third, the identification of vulnerable community groups that may experience substantive or differential social impacts; fourth, the anticipation, valuation, and forecast of social impacts affecting individuals and community groups; and finally, the review of alternatives and the design of mitigation measures that will permit this proposed development to proceed in a way that is equitable and meets the survival needs of all project-affected persons.[27,28,29]

Purpose and Components of ESIA

The Environmental and Social Impact Assessment is a systematic process for identifying, demonstrating, evaluating, and assessing internal and external environmental and social impacts and risks. The purpose of the Environmental and Social Impact Assessment is to set safe environmental and social practices for the project, to guarantee the integration of EIA indicators into the policies and programs of the project, and to improve the transparency of the participatory process and encourage stakeholder involvement. Typically, the system boundaries of ESIA focus on all direct, indirect, and cumulative impacts related to the construction and operation of the project.[23,30,31,32,33]

Compared with EIA, ESIA does not only focus on the impacts of environmental issues, but in addition, ESIA also includes social and economic issues such as labour, livelihoods impact, income, social and health security status, structural changes, conflicts associated with traditional cultural rights, and the impacts of land acquisition and resettlement. In the case of mining projects, due to the specific characteristics of the mining project, the ESIA is not only a baseline condition but also a basic evaluation indicator of mineral resources management and ecological environmental protection. The scope of the Environmental and Social Impact Assessment directly impacts admission conditions and profits of bank loans.[3,4,5,6,7,8]

However, the content of the Environmental and Social Impact Assessment has been a reflective topic. The main issue is how to measure the abnormal impact and set up the compensation evaluation of the adverse impact. In the carrying process of mining projects, the local people's values relate to the overall performance of the mining projects. However, traditional exploitation and management activities often damage natural resources and destroy ecological systems. As a consequence, the local community suffers from the changes in living conditions that are brought about by the mining project. Thus, ESIA aims to integrate local community demands into the project. The research on the ESIA of foreign mining projects focuses more on methodology and evaluation.[5,8,9,10,11,12,13]

The research topic is how to choose evaluation indicators and how to establish an evaluation mechanism. Some statisticians study different evaluation methods, and they combine other natural resource problems. The mainstream researchers paid more attention to the scale of the Environmental and Social Impact Assessment, and the treatment effects were ignored. Although some important issues of the Environmental and Social Impact Assessment can be found in the literature connected with mining projects in the Appalachian region and other problematic international regions, little attention is given to the local community problems in international mining projects.[13,33,34,35,36]

Importance of Community Engagement in ESIA

The recent language at the international level on 'community consultation' recognizes the need for local stakeholder engagement at all stages of industrial development projects. Key drivers behind community consultation are poverty reduction, economic growth, revenue and job creation, conflict resolution or peaceful coexistence, promoting good governance, and reducing crime and violence. An agreement negotiated with the security forces and the community residing within the area of the project forms part of this policy. Being recognized as 'partners' in the development process, as well as being part of the decision-making process, the pressure on government and corporations to meet the household needs of the people and reduce the development risks (social and conflict) will be greatly reduced. The corporation will gain greater assurances on the protection of critical infrastructure and the protection of life and assets. This responsibility also transfers to the corporation. Meeting the agreed development needs is an important part of securing the 'social license to operate'.[2,7,37]

In the African context, both Africa and South Africa have experienced political transitions that have resulted in the recognition of marginalized communities as important stakeholders within local development projects. A further reason why local stakeholders need to play such a crucial role in the social aspects and the impact of development is that it is the local community that needs to approve and vote, in both developed and underdeveloped countries. Policy approval by the local community must embrace true freedom of choice from the intense lobbying currently experienced during the annual public consultation process of national social and economic issues.[37,38]

Inadequate job and income-earning opportunities from key development projects will result in social discord. Properly managed and through continuous monitoring and reporting, social and economic community benefits

can heal trade unions, political parties, racial discrimination, and even ethnic favouritism. First, it is the right thing to do. However, if ethical practices are too distant, then the realization that social and economic benefits can create a stable community that is an asset to nation-building should direct policy. Once that realization takes place, the mitigation of social and economic risks can be used as a competitive tool relative to similar development opportunities.[37,39]

Most large-scale mining companies have a corporate responsibility with an accompanying support budget for environmental management.[32,37] For this reason, well-funded re-cultivation, livelihood restoration planning, and implementation are possible in such mining projects. In other large projects, integrated ecosystem approaches in which the participation of local communities is a requirement could yield success. The Local Integrated Ecosystem Management in the Limpopo Basin involves twelve communities in cultivating fruit trees on part of the restored area as a livelihood restoration plan.[34,36]

Successful Examples of Community Involvement

Local communities, especially those in low-income countries and mining areas, will continue to play an important role in monitoring compliance with laws and regulations in the future, with or without the use of consultants on mine project proponent payrolls. Furthermore, our impression is that the regulatory authorities in low-income countries foresee a continuing role for such community involvement.[39] As a general statement, the involvement of local community members in activities such as the periodic monitoring of infrastructure to determine ongoing environmental rehabilitation measures guards against the appearance of end-of-mine-life impacts that could have been avoided with proper management. Therefore, involving the local community in project-related activities, though local people have been doing it for many generations, is a path to sustainability.[40]

While the books that detail the province's long and important engagement in mining conclude with the invasion of European mining engineers during the colonial era, this research contends that the current path to sustainability for mineral development will extend local participation in project activities well beyond, some argue back to pre-colonial times.[41,42,43,44,45] While some may propose this path forward simply based on local rules, it seems more reasoned to look back at the overall success of these and modern projects, like gold standard projects, but with limited interventions, and then trace the reasons for success in local genomics without mining expertise. If this exercise reveals the involvement of non-mining enterprises, it presents a clear pattern for the stoppage of negative environmental changes.

CONCLUSIONS

Local communities in Sub-Saharan Africa hold essential knowledge and agency in safeguarding the environment during mining operations. This study emphasizes the need to strengthen their role in Environmental and Social Impact Assessments (ESIAs) through inclusive, participatory frameworks. Integrating artificial intelligence-particularly natural language processing and machine learning—can enhance transparency, detect institutional bias, and amplify community voices in ESIA processes. To reduce environmental risks and promote sustainable mining practices, stakeholders must move beyond symbolic consultation, empowering communities as co-regulators. AI should be adopted as a tool to support evidence-based, socially responsive, and culturally grounded environmental governance.

This study acknowledges three key limitations. First, the review focused exclusively on peer-reviewed empirical literature, which means that valuable insights from grey literature-including reports from NGOs, community-based organizations, and international development agencies—were not included. While these sources may offer important practical examples of community involvement in environmental safeguarding, their breadth and variability placed them beyond the scope of this systematic review.

Second, the exclusion of non-English publications may limit representation from certain SSA countries where relevant work is published in French or Portuguese, potentially omitting regionally significant cases of community-led environmental protection.

Finally, while the goal of this review was to synthesize evidence to inform a generalized thematic framework for understanding community roles in mining-related environmental governance, it does not claim to capture the full complexity or diversity of context-specific experiences. Rather than providing a definitive or exhaustive indicator set, this review aims to support place-based ESIA processes by offering flexible, evidence-based insights that can be adapted to local realities and priorities.

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FINANCING

The authors did not receive financing for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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