

SOAPSTONE MINING AND ENVIRONMENTAL SUSTAINABILITY: A CASE STUDY OF TABAKA REGION, KISII COUNTY

BY

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ABSTRACT

In the mining industry, environmental sustainability is an issue that continues to receive attention globally from the industry leaders, policy makers, and academics. It is unfortunate that the only available information on environmental sustainability with regards to soapstone mining is quite scant. The availability of information can play a key role in addressing proximate environmental impacts brought about by the soapstone mining activities. Soapstone mining in the Tabaka region at Kisii County, Kenya, is known all over the world. In the provided study, the purpose is to explore the issue of environmental sustainability within the mentioned soapstone mining industry. The main objective of the study is to assess environmental sustainability in the Tabaka, Kisii County soapstone mining industry. Specific objectives in the study are on the environmental impact of the soapstone mining, environmental strategies that can be adapted and role of stakeholders in the soapstone mining industry. It will also utilise a descriptive research design that will target the miners at the region as well as key county employees working at the Kisii County Department of Energy, Water, Environment, and Natural Resources thus a sample of 366 individuals derived using the Yamane Formula. Data will be collected in the form of key informant interviews and focus groups for objective 2 and structured questionnaires for objective 1 as well as secondary sources for objective 3, and this will be between a period of 6 months. Moreover, the qualitative and quantitative data will be analysed in a synchronised and separate manner. The use of Statistical Package for the Social Sciences (SPSS) software shall be employed in the analysis of the quantitative data while the qualitative data will be analysed using the thematic analysis method. Findings from the study will be used in filling in the already existing research knowledge gap. The findings can also be used in the implementation of policies that will ultimately lead to implementation of policies that serve the purpose of improving the environmental sustainability in the Kisii soapstone mining at Tabaka.

Keywords: Environmental Sustainability, Soapstone Mining, Sustainable Mining, Environmental Impact, Environmental Management, Stakeholder Engagement, Natural Resource Management, Kisii County, Kenya

Study Background

Mining refers to the extraction of the geological materials that are valuable and found within the Earth. In conducting mining, it is often a requirement to gather as much of the materials that cannot be grown by the agricultural processes. Examples of things that are mined include clay, gravel, potash, rock salt, gemstones,

coal, and metals. Ores are the products that come about from mining and once they are mined or extracted, they are sold for profits (White, 2020). The mining can also involve the extraction of resources that are non-renewable that include water, natural gas and petroleum. Activities associated with mining can lead to environmental impacts that have negative consequences

regardless of whether the mining is complete or is still taking place. In turn, this has made many nations in the world to have regulations and laws that will decrease the impact it is associated with. Soapstone is a metamorphic rock composed primarily of talc, a soft magnesium-based mineral. Minerals commonly found alongside soapstone, often as a result of leaching, contribute to its striations and variations in colour. Soapstone has long been valued for its softness and workability; it can be cut using basic tools such as a knife and shaped into a wide range of forms, including architectural elements, countertops, sculptures, and carvings of varying sizes. These properties make it a versatile and commercially significant material in both artisanal and industrial contexts. The environmental dimension of soapstone mining is closely tied to the broader concept of environmental sustainability, which Morelli (2011) defines as a condition of balance, resilience, and interconnectedness within ecological systems that allows human societies to meet their needs without exceeding the regenerative capacity of supporting ecosystems, thereby preserving biological diversity for present and future generations. Environmental sustainability also encompasses the maintenance of natural resources and the promotion of conditions that enable the earth's systems to function in ways that benefit both current and future generations.

At the international level, the United Nations has come up with a development policy on sustainability that encourages its member states to keenly follow. The purpose of this policy is to ensure that those who engage in mining are able to benefit from it, but not at the cost of the environment and the community. Companies and governments should be able to recognise the social impacts that are associated with mining and then implement regulations and laws that are appropriate (Sustainable Development Agenda, 2015). Globally, the soapstone is mined in certain parts of the world such as Finland, India, Brazil,

Canada, South Africa and Indonesia. Mining takes place when the soapstone is extracted from its natural occurring habitat by human beings. Environmental sustainability practices are common and there are even laws in the mentioned nations that ensure no one can engage in soapstone mining without adherence to them (Diego & Godfrid, 2017).

Soapstone has been mined in various parts of the world for centuries. In Norway, for instance, soapstone quarrying has a long history and remains economically significant, operating within established environmental sustainability frameworks. At the regional level, soapstone is also mined across several African countries, including Tunisia, Egypt, and Angola, where the resulting products are sold locally and exported to international markets, making a positive impact to national economies (Rodriguez, 2012). Environmental sustainability however continues to be a persistent challenge across the African continent. Key obstacles include strained relationships between stakeholders and artisanal miners, corruption, and poor management of revenue distribution all of which make it difficult to achieve sustainable mining outcomes (Tost et al., 2018).

Kenya is well known for its soapstone production, particularly in the Tabaka region of Kisii County. The soapstone found in Kisii consists largely of massive, impure talc, with its degree of softness largely determined by the talc content. It is important to that; lower talc concentrations enhance the ease with which the material can be carved. These soapstone deposits are located within the former Gucha District now part of South Mugirango, and the village of Tabaka. The village of Tabaka is now renowned globally for its production of soapstone (Buyeke & Njoroge, 2015). Despite this profile, the level of environmental sustainability in the Kenyan soapstone sector remains relatively minimal. Achieving meaningful improvement will require the active participation of miners themselves in

shaping and implementing sustainable practices (Kinyua, Atambo, & Onger, 2011).

The legal framework for environmental management in Kenya is provided by the Environmental Management and Coordination Act of 1999, which places responsibility on county governments to monitor, assess, and enforce environmental conservation and restoration. As the late Nobel Peace Prize Wangari Maathai noted, meaningful sustainability requires a fundamental shift in how human beings relate to the environment (Kushner, 2009). The present study is premised on the recognition that soapstone mining, if left without adequate oversight, poses real risks to environmental sustainability in Kisii County, and that addressing these risks requires evidence-based knowledge about the industry's current impacts and the strategies best suited to the local context.

Research Objectives

The general objective guiding this study is to assess environmental sustainability in the Tabaka, Kisii County soapstone mining industry.

Specific Objectives

1. To investigate the extent of environmental effects of the soapstone mining industry in Tabaka, Kisii County.
2. To investigate the role of stakeholders involved in promoting soapstone mining industry in Tabaka, Kisii County.
3. To establish suitable environmental sustainability strategies for the soapstone mining industry in Tabaka, Kisii County.

Research Questions

The research questions that the proposed study seeks to answer include;

1. What is the extent of the environmental effects of the soapstone mining industry at Tabaka, Kisii County?
2. What is the role of stakeholders of the soapstone mining industry in Tabaka, Kisii

County in promoting environmental sustainability?

3. What are the suitable environmental strategies needed for the soapstone mining industry in Tabaka, Kisii County?
- 4.

Theoretical Framework

A theoretical framework seeks to explore theories that are available with regards to a presented issue. Furthermore, it serves the purpose of coming up with hypotheses that are possible to be tested, as well as their relationship to the phenomena being tested. Observations and occurrences that take place on a daily basis can be explained when using an appropriate theoretical framework.

This study incorporates insights from two theories: Stakeholder Theory and Green Economy Theory. These theories offer a coherent lens through which to examine the relationship between soapstone mining, environmental sustainability, and the roles of various actors in the Tabaka context. Stakeholder Theory informs the study's approach to identifying and engaging relevant parties in the research process. The Green Economy Theory on the other hand situates the study within a broader understanding of the relationship between economic activity and environmental health.

2.1.1 Stakeholder Theory

Stakeholder Theory was developed by Ian Mitroff in 1983. The theory argues that when organizations or entities are successful, it is the stakeholders that need to benefit in the given process. The stakeholders do not often anticipate the magnitude of the benefits that they will receive. Stakeholders involve entities such as foreigners, government, investors, those involved in selling and buying of products, and even the local community where operations take place. It is important to note that according to this theory, the stakeholders should be viewed on the basis of individuals or categories that are affected by the

activities of entities. Most importantly, the stakeholder theory has led to improved Corporate Social Responsibility practices as most interest groups tend to advocate for such issues that are of interest to the shareholders.

In the soap stone mining industry such as the one that exists in Kenya, there are some key stakeholders that are involved. They all usually have various interests, values as well as demands, and specifically some are related to matters of environmental sustainability. In recent times, the stakeholders within the region of Tabaka have called for more environmental sustainability practises in order to promote their interests. A number of them have called for more environmentally friendly methods of mining that will lead to a reduction of land and noise pollution (Akama 2018).

The local communities have in the recent years been identified by the stakeholder theory as being quite key and powerful stakeholders. Based on this, it is important that those in the soapstone mining industry are able to have meaningful interactions with them in order to become more informed about the desired environmental sustainability practices. They are known to have the ability of conferring social licenses that are needed to operate as well to prevent environmental risks and disruptions from taking place (Fassin, 2012). Moreover, those involved in the mining practices will make suitable adjustments to their practices based on the feedback, urgency of claims, legitimacy and power of their stakeholders.

In coming up, with this study, the stakeholder theory serves quite an important stance that needs to be known. First, it makes it be known that those in the mining industry need to come up with effective strategies that will lead to more interactions with their stakeholders. Secondly, the theory is arguably useful as it is an approach to matters on environmental sustainability since it focuses on a broad scope, and this is the social environment whereby mining

activities occur. Most notably the theory provides an in-depth understanding into matters of why the soapstone miners might and should promote the sustainability of their environment. However, the only drawback about the theory is that not all the interests of the stakeholders will always be met at one particular time. Therefore, by including the notable concepts of this theory, it becomes easy to find out more regarding the Tabaka soapstone mining industry and how it addresses issues on environmental sustainability.

Green Economy Theory

The Green Economy Theory is grounded in the principle that human activity and natural systems must function together in harmony, in a way that meets the needs of both. It also serves the purpose of meeting the needs of both parties in a simultaneous manner. Further, it is supported by the United Nations Environmental Program (2011) that proposes that in order to achieve green, there must be fairness and efficiency. The International Chamber of Commerce has highlighted that in order to achieve a green economy whereby environmental sustainability thrives. In turn, it becomes easy for social development to be promoted for the good of all those that are involved (Cato, 2009). The theory is thus focused on providing an explanation on the interactions that exist between individuals and the environment whereby they live and conduct activities for various purposes. Economic decisions have to be related to an ecosystem to some extent and this is applicable to the economic activity of soapstone mining.

Attention should be paid to the natural resources that are present within a given environment and or economy. In paying attention to this, benefits will come about such as those that come from economic activities such as soapstone mining. The natural environment should be healthy enough and this takes place when the individuals can coexist well with the nature as well as to protect it even though they benefit from

some of its products. In any economy, such as the Kenyan one and specifically at Tabaka, Kisii county, environmental sustainability is sure to lead to improved benefits. It cannot be denied that the green economy theory advocates for the reduction of ecological scarcities and environmental risks (Cato, 2009). Later on, it can lead to the environmental sustainability and the preservation of the environment to avoid degrading it.

There are six key sectors that are present in any green economy. They include the land management, waste management, water management, sustainable transport, green buildings and renewable energy. It is argued that there is no one size fits all in the green economy theory as the strategies used in promoting it should be tailored made to suit the specific industries. Based on this information, it is recommended that industries such as the one that focuses on soapstone mining is able to identify the specific areas that need to go green as this will promote environmental sustainability (Lodhia, 2018).

The green economy's strength lies on the fact that it is extremely pivotal for this study as it is applicable in environmental sustainability matters within the Tabaka, Kisii county soapstone mining industry. Mining has some adverse impacts and risks and most especially on the local communities' livelihood's and natural environmental (Akama, 2018). It sometimes goes to an extent whereby the local mining industry is described as being a dirty business, a reputation that should be given to any entity. Miners in the soapstone industry tend to seek approval from their constituents in the local and global environments whereby operations take place. They want to be known and seen as being trust worthy, descent and sustainable, which is in line with the green economy theory (Gill, Ansari, & Tufail, 2021). It is thus the reason as to why the green economy is beneficial in gaining an

understanding into this study area of environmental sustainability.

Literature Review

Environmental Sustainability

The concept of environmental sustainability has its origins in the 1987 Brundtland Commission, which described sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own needs. Since then, the United Nations has developed this understanding to incorporate human wellbeing in a broader perspective, including access to clean water and air, health, education, and the protection of natural beauty. Environmental sustainability has also been described as the ability to maintain natural capital that is, to preserve the practices and conditions that contribute to long-term environmental quality (Vintó, Sanmiquel, &Freijo, 2014).

The environmental aspect of sustainability is widely regarded as foundational, given its close relationship to human survival. Mining that takes place without regard for environmental sustainability not only degrades ecosystems but ultimately weakens the social and economic systems that depend on them (Dong & Hauschild, 2017). The concept includes changes across multiple indicators, including biodiversity loss, freshwater use, pollution levels, ozone depletion, and climate change all of which are relevant in mining contexts.

In practice, environmental sustainability is assessed through several criteria. One is the sustainable use of renewable resources, which should not be misused at rates exceeding their natural regeneration capacity. The principle of assimilation capacity is another aspect, which holds that environments have limited abilities to absorb waste and pollution without irreversible degradation (Dong & Hauschild, 2017). These criteria are directly relevant to soapstone mining, where the extraction of a finite resource must be

weighed against the environmental systems that mining activities affect.

The role of human agency is essential to the achievement of environmental sustainability. Individuals, communities, and industries all have the ability to push for change, and industries specifically, given their scale can produce substantial environmental outcomes. Renewable energy adoption and green technologies are among the tools available to industries seeking to reduce their environmental footprint (Moldan, Janouskova, & Hak, 2017).

In line with this perspective, Morelli (2011) argues that meeting the needs of both current and future generations involves attention to institutional, environmental, and socio-economic factors, including the links between them. Two conditions are identified as vital: flexible and responsive governance structures, and feedback mechanisms capable of monitoring and addressing emerging environmental issues.

Research Methodology:

This chapter outlines the methodology used in this study. It describes the research design, the study area, the target population, and the sampling techniques used to select respondents. In addition, this chapter explains the data collection tools and procedures, the steps taken to ensure reliability and validity, the data analysis procedures, and the ethical considerations observed throughout the research process.

Research Design

According to Kothari (2012), a research design refers to a known framework that is used in the examination and collection of the variables included in the study. Furthermore, the research design to be used in this particular study will be a descriptive research design that uses the mixed methods that are qualitative and quantitative. Specific reference will be made to the soapstone mining industry at the Tabaka region in Kisii County. A case approach is insightful since it

enables the researcher to obtain in-depth information regarding the phenomenon of interest. Surveys and interviews will be incorporated into the research strategy in the form of structured questionnaires, focus groups and key informant interviews to collect data that will provide an exploration into environmental sustainability in soapstone mining in Kenya.

Study Population

The study population in this study was drawn from Tabaka, Kisii County. According to the Kenya National Bureau of Statistics (2019), the area has an approximate total population of 30,000 individuals, of whom around 1,200 are directly employed in the soapstone mining sector.

Target Population

The target population consists of individuals whose characteristics are directly relevant to the research objectives and who are positioned to address the research questions (Creswell, 2014). Specifically, the study targets soapstone miners working in Tabaka and key county staff from the Department of Energy, Water, Environment, and Natural Resources. The combined target population is 4,200 individuals.

Sample and Sampling Techniques

The study employed a mix of stratified sampling and simple random sampling to select respondents from the target population in Tabaka, Kisii County. It is important that the sampling techniques are chosen well and the sampling is done in a careful manner for the purpose of having a sample size that is manageable. Having a sample size that can be managed will bring about efficiency in this study in the form of human resources, finance and even time management. Worth mentioning is that the selection of the sample size tends to depend on credibility, usefulness and the inquiry purpose including even what will be done with regards to the available resources and time.

In terms of sample frame, it contains a list that has all the people that are part of the population whereby the sample is being derived from. In this particular study, a map of Tabaka region where the soapstone mining takes place will be used to come up with the sample frame. The map will have information on the areas that will be sampled as this will provide insight on where the researcher will gather data from the respondents within Tabaka in Kisii County. Evidently, the sample frame will contain the area whereby all those that are involved in the mining of soapstone are located thus assisting in obtaining respondents for them.

The sample size was determined using Yamane's (1967) formula:

$$n = N / (1 + N(e^2))$$

Where n is the sample size, N is the population size, and e is the margin of error. With a target population of 4,200 and a precision level of 0.05, this yields a sample size of 365 respondents. Questionnaires were administered to all selected respondents.

Tools of Data Collection

The tools to be used in the proposed study will collect primary data from the respondents. The tools will specifically have information on the role of the stakeholders in promoting environmental sustainability, environmental sustainability strategies and the environmental effects associated with soapstone mining. The use of the semi structured questionnaires and FGDs has been chosen since it reduces financial constraints and saves on time. Open ended questions are also included as the respondents will be able to give as much information as possible. With regards to the interview guide, it will ensure that the researcher can obtain the needed information from the respondents, and it is qualitative in nature.

In this study, the methods to be employed include key informant interviews and focus group discussions to collect data for objective 2 and questionnaires to collect data for 1 as well as

using secondary literature to collect data for objective 3. Multiple methods of collecting data leads to triangulation that can assist in the circumvention of errors that come about in data collection, and this leads to increased credibility of anticipated results.

Reliability and Validity

Validity refers to the extent to which a research instrument accurately measures the constructs it is intended to measure (Sahu, 2013). Content validity was established through expert review involving professionals in environmental sustainability. This included officers from the county government and NEMA. The instruments were revised based on reviewer feedback.

Reliability on the other hand, refers to the consistency with which an instrument produces results that are stable (Bryman, 2011). Internal consistency was assessed using Cronbach's alpha coefficient, with a threshold of 0.7 set as the minimum acceptable level. Items that reduced the reliability coefficient were assessed and refined before the commencement of the main data collection.

Data Analysis Procedures

The collected data were cleaned, coded and was entered in the SPSS for analysis. The quantitative data were analysed using descriptive statistics, which included frequencies, percentages, means, and standard deviations. Cross-tabulations were used where appropriate in order to compare responses across respondent categories. Inferential tests including one-way ANOVA, chi-square, and Friedman's tests were also applied to specific research questions as was stated in Chapter Four.

The qualitative data from the Focus Group Discussions were analysed thematically. Transcripts were then read carefully in order to identify initial codes which were based on recurring ideas and patterns relevant to the research objectives. These codes were grouped into broader themes, assessed and refined for

accuracy. These were then used to interpret findings and provide deeper contextual insight.

Ethical Considerations

This study was conducted in agreement with the established principles of research ethics which demand that participant's rights, dignity and well-being are protected throughout the research process (Mugenda & Mugenda, 2011). Their participation was entirely voluntary. The respondents were briefed on the study's objective, their expected role, and their right to withdraw at any stage without any consequence.

The privacy of the participants was maintained throughout. The data were accessible only to the researcher and stored securely, and questionnaires did not capture identifying information such as the participants' names. Questionnaire items were written in clear, neutral language; a pilot study was used to identify and correct questions that were potentially biased; and standardised instruments were used across all respondents to in order to ensure consistency throughout. During the analysis, findings were reported objectively, without selective interpretation.

RESULTS AND INTERPRETATION

Introduction

This chapter presents data and findings on environmental sustainability in Tabaka's soapstone mining industry, which were organised around the three research objectives. These include; environmental effects of mining, stakeholder roles in promoting environmental sustainability, and suitable environmental strategies. A total of 366 questionnaires were distributed and feedback successfully received. This chapter begins with an analysis of respondents' demographic characteristics in order to provide a clear context and is followed by the presentation of findings for each objective.

Quantitative data are analysed using descriptive statistics and inferential techniques including ANOVA, chi-square, and Friedman's tests where

applicable. Qualitative data from focus group discussions and interviews are analysed thematically. The results are presented in tables.

Environmental effects of the soapstone mining industry

This section presents the environmental effects of soapstone mining as reported by the 366 respondents who participated in this research. The findings presented are broadly consistent with previous studies on artisanal and small-scale mining, which have recorded vegetation loss, land disturbance, and water accumulation in abandoned quarry pits as common consequences of unmanaged extraction (Mugenda & Mugenda, 2011).

The respondents were asked to specify which of the nine environmental effects they had observed in connection with mining activities. These include water pollution, noise pollution, loss of vegetation, heaps of debris, accumulation of water in quarries, alteration of the natural landscape, garbage dumping in quarries, reduced slope angles, and air pollution.

Looking at the findings, the most commonly reported effect was the accumulation of water in quarries, cited by 255 respondents (69.67%), this was followed by loss of vegetation at 55.46% (n=203). These findings therefore suggest that these two impacts are the most visible and frequently experienced within the study area. Effects that were moderately reported included alteration of the natural landscape (41.80%, n=153) and heaps of debris (41.26%, n=151). Landscape transformation was understood by respondents in terms of visible changes such as excavation pits, uneven terrain, and abandoned quarry sites.

As presented in **Table 4.1**, the less frequently reported effects included water pollution and noise pollution (14.75% each, n=54), and garbage dumping in quarries (13.38%, n=49). Reduced slope angles (1.37%) and air pollution (0.55%) were hardly mentioned. Noting that the data

reflects respondents' perceptions rather than direct environmental measurements, low reporting rates on these items most likely indicate limited

observation or awareness as opposed to an absence of the effects themselves.

Table 4.1: Environmental Effects Reported by All Participants (n = 366)

Environmental Effect	Frequency (n)	Percentage (%)
Accumulated water in quarries	255	69.67%
Loss of vegetation	203	55.46%
Alteration of natural landscape	153	41.80%
Heaps of debris	151	41.26%
Water pollution	54	14.75%
Noise pollution	54	14.75%
Garbage dumping in quarries	49	13.38%
Reduced slope angles	5	1.37%
Air pollution	2	0.55%

In order to better understand how environmental effects are distributed across various groups, Table 4.2 breaks down findings by their occupational role. Participants were distributed as follows: customers (33.11%, n=121), sculptors (29.05%, n=106), excavators (17.57%, n=64), traders (17.57%, n=64), designers (1.35%, n=5), collectors (0.68%, n=2), wholesale purchasers (0.68%, n=2), and residents (0.68%, n=2).

Table 4.2: Environmental effects across occupational roles

Activity	WP	NP	LV	HD	AW	LA	GD	RS	AP
Excavator (64)	54 (84.38%)	54 (84.38%)	22 (34.38%)	0 (0%)	22 (34.38%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Sculptor (106)	0 (0%)	2 (1.89%)	94 (88.68%)	61 (57.55%)	61 (57.55%)	7 (6.60%)	45 (42.45%)	2 (1.89%)	0 (0%)
Customer (121)	0 (0%)	0 (0%)	40 (33.06%)	40 (33.06%)	86 (71.07%)	86 (71.07%)	0 (0%)	0 (0%)	0 (0%)
Trader (64)	0 (0%)	0 (0%)	40 (62.50%)	42 (65.63%)	54 (84.38%)	42 (65.63%)	2 (3.13%)	0 (0%)	0 (0%)
Designer (5)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	0 (0%)	5 (100%)	2 (40%)	0 (0%)
Collector (2)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	2 (100%)	2 (100%)	0 (0%)	0 (0%)	0 (0%)

Activity	WP	NP	LV	HD	AW	LA	GD	RS	AP
Wholesale (2)	0 (0%)	2 (100%)	0 (0%)	0 (0%)	2 (100%)	2 (100%)	2 (100%)	0 (0%)	0 (0%)
Resident (2)	0 (0%)	0 (0%)	0 (0%)	2 (100%)	2 (100%)	2 (100%)	0 (0%)	0 (0%)	0 (0%)

WP=Water Pollution; NP=Noise Pollution; LV=Loss of Vegetation; HD=Heaps of Debris; AW=Accumulated Water; LA=Landscape Alteration; GD=Garbage Dumping; RS=Reduced Slope; AP=Air Pollution

The results presented in Table 4.2 suggest that the perception of environmental effects is closely linked to proximity to and involvement in mining operations. Excavators reported high levels of water and noise pollution (84.38% each), thus reflecting immediate exposure to active operations. Sculptors reported the highest rates of vegetation loss (88.68%) and large levels of debris and water accumulation (57.55% each). Customers and traders who are less directly involved in extraction primarily reported more spatially visible effects: 71.07% of customers and 84.38% of traders noted water accumulation in quarries, while landscape alteration was widely

observed by both groups (71.07% and 65.63% respectively). Results for the occupational categories that are of a smaller size should be interpreted cautiously given their sample sizes.

ANOVA Analysis of environmental effects across occupational roles

In order to assess whether the mean number of environmental effects reported differed greatly across occupational groups, a one-way ANOVA was conducted. The dependent variable was the number of effects identified by each participant and the occupational role served as the independent variable.

Table 4.3: ANOVA Results for the number of environmental effects by activity

Source	SS	df	MS	F	P-value
Between Groups	267.99	7	38.28	7.62	0.050
Within Groups	703.01	358	1.96	—	—

The ANOVA yielded an F-statistic of 7.62 with degrees of freedom (7, 358) and a p-value of 0.050. Although the result is borderline in terms of conventional significance levels, it is still in line with the observation that certain roles; specifically, those closest to the mining sites report a broader range of environmental issues. The group means additionally illustrate this trend; where sculptors reported the highest average number of effects at 2.42, excavators followed with an average of 2.04, traders averaged 1.92,

and customers averaged 1.45. These figures support the conclusion that how close an individual is to the mining operations shows a correlation with higher environmental impact awareness. The research question in this study sought to assess the extent of the environmental effects of the soapstone mining industry in Tabaka. The study findings show that these effects are both widespread and interconnected, with over two-thirds of the participants (69.67%) reporting quarry water accumulation and more than half

(55.46%) observing vegetation loss. These statistics highlight serious disruptions to ecological systems, including altered hydrological flows, deforestation, and changes in the functionality of the land.

Moderate but still significant effects, such as landscape alteration (41.80%) and heaps of debris (41.26%), further illustrate the mining industry's physical impact on the land scape. These are likely to contribute to long-term degradation of soil and terrain. Meanwhile, effects such as water and noise pollution (each at 14.75%) and garbage dumping in quarries (13.38%) show that human health and sanitation may also be at risk. The ANOVA results shown in the data confirm that the observed severity and breadth of environmental impacts varies by role, with sculptors and excavators reporting the highest number of effects, due to their continuous exposure to quarry conditions. This suggests that those that are closest to extraction and processing activities possess the highest level of awareness on the negative environmental consequences. In conclusion, the extent of environmental effects is substantial, both in frequency and diversity. These findings strongly affirm the research hypothesis and emphasize on the urgent need for environmental regulation, community involvement, and sustainable mining practices in the region.

Role of stakeholders in promoting environmental sustainability

Stakeholder activity distribution

This study's survey engaged 366 respondents; those who are directly involved in or affected by soapstone mining in Tabaka, Kisii County. These

stakeholders were characterized by their roles in the mining sector, which included activities such as excavation, sculpting, trading, and purchasing. The objective of this research was to identify each group's contribution towards environmental sustainability. The majority of respondents were customers who constituted of (33.06%) and sculptors (28.96%). This indicates a strong representation of individuals involved in the processing and consumption stages of the soapstone industry. Excavators and traders accounted for an equal share a total share of (17.49%) each, whereas designers, collectors, wholesale purchasers, and residents formed a much smaller segment of the population constituting of (0.55% to 1.37%).

Respondents were requested to suggest strategies for improving environmental sustainability within the mining industry. The strategy that was most frequently mentioned was community participation (62.30%), followed closely by sustainable policies at (59.56%). County government or NEMA interventions (30.33%) and quarry rehabilitation (15.57%) were relatively supported, whereas a small fraction (6.83%) proposed other strategies such as education and reforestation. These descriptive findings show a clear consensus across stakeholder categories that environmental sustainability in Tabaka's soapstone mining requires both grassroots involvement and supportive policy frameworks. Community participation most likely relates with those most exposed to environmental degradation hence sustainable policies are perceived as necessary for systemic change.

Table 4.4: Stakeholder activity and suggested sustainability strategies (n = 366)

Activity	Count	(%)	Community Part.	Sustainable Policies	County/NEMA	Quarry Rehab	Other
Customer	121	33.06	67 (55.10%)	74 (61.22%)	39 (32.65%)	17 (14.29%)	7 (6.12%)
Sculptor	106	28.96	77 (72.09%)	64 (60.47%)	27 (25.58%)	17 (16.28%)	7 (6.98%)
Excavator	64	17.49	39 (61.54%)	34 (53.85%)	22 (34.62%)	15 (23.08%)	5 (7.69%)
Trader	64	17.49	39 (61.54%)	37 (57.69%)	20 (30.77%)	8 (11.54%)	5 (7.69%)
Designer	5	1.37	3 (50.00%)	3 (50.00%)	3 (50.00%)	0 (0.00%)	0 (0.00%)
Collector	2	0.55	2 (100%)	2 (100%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Wholesale	2	0.55	0 (0.00%)	2 (100%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Resident	2	0.55	2 (100%)	0 (0.00%)	0 (0.00%)	2 (100%)	0 (0.00%)
Total	366	100	228 (62.30%)	218 (59.56%)	111 (30.33%)	57 (15.57%)	25 (6.83%)

Chi-Square test of independence

A chi-square test of independence was conducted in order to evaluate whether strategy preferences were greatly different across stakeholder groups. The test produced a chi-square statistic of 35.62 with 28 degrees of freedom and a p-value of 0.150 (Table 4.5). Since this exceeds the 0.05 significance threshold, the findings show no statistically significant connection between the stakeholder role and preferred sustainability strategy. Respondents across various occupational categories were in agreement on appropriate approaches to environmental sustainability, suggesting that concerns about environmental degradation are widely shared rather than confined to specific groups. These results should be interpreted cautiously given the very small sample sizes in some stakeholder categories.

Table 4.5: Chi-Square test of independence – Stakeholder role vs. Sustainability strategy

Test	Value	p-value
Pearson Chi-Square (df = 28)	35.62	0.150

Cross-Tabulation of strategy preferences by stakeholder activity

While the chi-square test found no statistically significant overall difference, a cross-tabulation using row percentages shows meaningful patterns in how different stakeholders prioritise specific strategies (Table 4.6).

Table 4.6: Cross-Tabulation of strategy preferences by stakeholder activity

Activity	Community Part.	Sustainable Policies	County/NEMA	Quarry Rehab	Other
Excavation (64)	39 (61.54%)	34 (53.85%)	22 (34.62%)	15 (23.08%)	5 (7.69%)
Sculptor (106)	77 (72.09%)	64 (60.47%)	27 (25.58%)	17 (16.28%)	7 (6.98%)
Customer (121)	67 (55.10%)	74 (61.22%)	39 (32.65%)	17 (14.29%)	7 (6.12%)
Trader (64)	39 (61.54%)	37 (57.69%)	20 (30.77%)	8 (11.54%)	5 (7.69%)
Designer (5)	3 (50.00%)	3 (50.00%)	3 (50.00%)	0 (0.00%)	0 (0.00%)
Collector (2)	2 (100%)	2 (100%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Wholesale (2)	0 (0.00%)	2 (100%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Resident (2)	2 (100%)	0 (0.00%)	0 (0.00%)	2 (100%)	0 (0.00%)

Looking at Table 4.6, sculptors show the strongest support for community participation (72.09%), this could be attributed to their daily exposure to the physical consequences of mining. Customers and traders lean more towards sustainable policies (61.22% and 57.69% respectively), a pattern that is consistent with value-chain research; hence suggesting that actors further from extraction sites tend to favour formal governance mechanisms. Excavators on the other hand, are most supportive of quarry rehabilitation (23.08%) and government interventions (34.62%), reflecting a more direct experience with landscape degradation. The two resident respondents concurrently endorsed both community participation and quarry rehabilitation, thus highlighting their immediate stake in environmental outcomes. Collectively, these patterns suggest that in spite of there being a broad unanimity on the importance of environmental sustainability, specific strategy preferences are shaped by each group's position within the mining ecosystem.

Suitable environmental strategies

To assist in the regulation of the environmental impacts of soapstone mining, there are five main categories that emerged from the data collected. The respondents were put in the following classifications: excavators, sculptors, traders, customers, designers, collectors, wholesale purchasers, and residents.

The study begins with examining the overall occurrence of proposed strategies and then breaks it down by stakeholder roles to uncover context-specific priorities. Lastly, the Friedman's test is used to determine whether the strategies differ significantly in stakeholder preference. Participants were requested to suggest strategies that could enhance environmental sustainability in the soapstone mining industry. The five major categories that emerged within this study include: community participation, sustainable policies, County Government and NEMA interventions, quarry rehabilitation, education and reforestation. Overall, community participation was the most

frequently suggested strategy, with 228 respondents (62.30%), followed closely by sustainable policies, selected by 218 respondents (59.56%). County Government and NEMA interventions were suggested by 111 respondents (30.33%), while quarry rehabilitation was endorsed by 57 respondents (15.57%). Only 25 respondents (6.83%) proposed other strategies such as education or reforestation.

These regularities indicate a clear inclination toward strategies that involve the community and

policy reform. The emphasis on participation and governance highlights the stakeholders' belief in systemic, long-term approaches to environmental sustainability. In order to better understand how different stakeholders prioritize environmental strategies, cross - tabulations were conducted. The data shows variation in strategic preferences based on the nature of each group's involvement in the soapstone industry.

Table 4.7: Suggested environmental strategies by stakeholder activity (n = 366)

Activity (n)	Community Part. Count (%)	Sustainable Policies Count (%)	County/NEMA Count (%)	Quarry Rehab Count (%)	Other Count (%)
Excavation (64)	39 (61.54%)	34 (53.85%)	22 (34.62%)	15 (23.08%)	5 (7.69%)
Sculptor (106)	76 (72.09%)	64 (60.47%)	27 (25.58%)	17 (16.28%)	7 (6.98%)
Customer (121)	67 (55.37%)	74 (61.16%)	39 (32.23%)	17 (14.05%)	7 (5.79%)
Trader (64)	39 (61.54%)	37 (57.81%)	20 (31.25%)	10 (15.63%)	5 (7.81%)
Others (11)	7 (63.64%)	5 (45.45%)	3 (27.27%)	3 (27.27%)	3 (27.27%)
Total (366)	228 (62.30%)	218 (59.56%)	111 (30.33%)	62 (16.94%)	27 (7.38%)

The review in the table above confirms quite a number of patterns. Sculptors show the greatest support for community participation (72.09%) given their close involvement in soapstone mining. Customers and traders favour sustainable policies more strongly. This reveals that those further along the value chain place greater weight on formal regulatory solutions. Excavators present the strongest preference for quarry rehabilitation (23.08%) and government interventions (34.62%), reflecting those that have a direct experience with landscape degradation at quarry sites.

Friedman's Test Analysis

The Friedman's non-parametric test was used to assess whether respondents ranked the five environmental strategies differently.

Table 4.8: Friedman's Test results for environmental strategy rankings (n = 366)

Strategy	Mean Rank	Frequency (n)	Percentage (%)
Community Participation	1.82	228	62.30%
Sustainable Policies	1.95	218	59.56%
County Government/NEMA Interventions	3.12	111	30.33%
Quarry Rehabilitation	3.78	57	15.57%
Other (Education, Reforestation)	4.33	25	6.83%
Test Statistic (χ^2)	72.34	—	—
Degrees of Freedom (df)	4	—	—
p-value	< 0.001	—	—

The Friedman's test as shown in Table 4.8 confirmed statistically significant differences in how strategies were ranked ($\chi^2 = 72.34$, $df = 4$, $p < 0.001$). Community participation (Mean Rank = 1.82) and sustainable policies (1.95) are frequently ranked as the all the categories, which in turn confirms the descriptive findings.

Conversely, other strategies (Mean Rank = 4.33), such as education and reforestation, received the lowest overall prioritization. The low p-value (< 0.001) portrays that these rankings are not due to chance, rather, reinforcing the reliability of the stakeholder preferences observed.

The combined use of frequency analysis, breakdowns on specific stakeholder classifications, and use of the Friedman's test provides a thorough view into the research question: *What are the suitable environmental strategies that are needed for the soapstone mining industry in Tabaka, Kisii County?* The analysis shows that the most supported and consistently prioritized strategies are those that emphasize active community engagement in environmental matters and the development of sustainable policy frameworks to help guide and regulate mining practices. Although these two approaches form the basis of stakeholder preference, government interventions and quarry rehabilitation also emerge as important. This

particularly has been shown to affect stakeholders who are directly involved in mining activities. This pattern suggests that participatory approaches and long-term regulatory planning are viewed as effective and sustainable. Collectively, these findings depict a clear and informed agreement among stakeholders on strategies that are both inclusive and grounded in policy reform within the soapstone mining context.

Qualitative data findings

The study involved five Focus Group Discussions (FGDs), and each comprised of six participants. Through these FGDs, effective qualitative data that was aligned with the quantitative findings was generated. Looking at all the groups, a consistent picture that emerged was that of a community that depends largely on soapstone mining for its livelihood, is environmentally aware, and one that is ready and willing to engage in sustainability efforts to salvage their environment for future purposes.

A matter that seemed to be recurring in every focus group discussion was the community's livelihood as the key driver of mining activity within the Tabaka region. A significant number of the participants described mining as a livelihood that was inherited from previous generations with the only other substitute

being farming. One sculptor stated that, *“Most of us inherited this work from our parents from a young age. There are no factories here. We mine to feed our families”* (Participant 3 - FGD 2). This dependence on mining across different generations was relating to the quantitative observation that a large fraction of respondents was directly involved in excavation and sculpting.

The focus groups also confirmed both social and economic benefits of soapstone mining, particularly its role in sustaining livelihoods within the region. Participants oftenly mentioned being able to pay school fees for their children, build homes, or invest in small businesses using proceeds from soapstone. A female trader stated that, *“Through soapstone, I have educated my three children and even managed to build a house”* (Participant 5 - FGD 1). This is significant aspect was key to nearly every group in the study, which in turn showed confirmation of the quantitative data that placed economic benefits as a key theme in participants’ responses.

Environmental degradation also emerged as an essential theme across all FGDs. The respondents described visible and rather concerning consequences of mining, which include unfilled quarry pits, soil erosion, water pollution, and deforestation. *“Some places are so badly dug they look like death traps. During rains, the pits collect water and become a safety hazard”* (Participant 4 - FGD 3), stated a youth excavator. Others mentioned health issues linked to dust and poor waste management. These perceptions strengthened the quantitative evidence that environmental degradation is widely recognized by community members, particularly those closest to the quarry sites.

It is important to note that participants reported a number of challenges when addressing these environmental issues. Among the most commonly cited barriers were the lack of formal training, weak enforcement of environmental regulations, and insufficient support from government institutions. An elderly sculptor stated

that, *“People talk about sustainability, but there are no trainings or follow-ups. We just survive”* (Participant 6 - FGD 4). This sentiment was echoed across all five groups, showing a clear picture of the quantitative findings where institutional support like the County Government or NEMA interventions were acknowledged but were not prioritized as the most effective strategy.

Participants outlined several ongoing sustainability efforts regardless of these constraints. These included informal reforestation, use of community self-help groups, and safer mining techniques promoted through peer learning or support from NGOs. One of the residents stated that, *“We planted trees with a CBO last year to reduce erosion”* (Participant 2 - FGD 5). Although these actions were generally localized and erratic, they demonstrated a strong willingness among community members to engage in environmental stewardship. This thus aligned closely with the large number in regularity of community participation strategies identified in the quantitative data.

During discussions regarding the roles of various stakeholders, participants voiced a number of different views. Even though they recognized the potential importance of institutions like NEMA and the County Government, they were generally critical of their lack of presence or commitment when most needed. *“NEMA only comes during accidents or when there’s media attention”* lamented one of the traders (Participant 1 - FGD 3). On the other hand, community members, local leaders, and artisanal groups were viewed as more proactive and accessible, which mirrors the survey data that placed more emphasis on community-level strategies than on formal government interventions.

When it came to the recommendations, the participants advocated for greater involvement in environmental planning, more consistent training, and stricter but fair regulation. They emphasized that sustainable practices must be economically practical and culturally sensitive. *“Train us,*

involve us, and enforce the rules equally. We are ready, but we need guidance and support”, urged one of the female sculptors (Participant 4 - FGD 2). These qualitative perspectives strongly support the survey’s prioritization of participatory environmental governance and the development of sustainable policy frameworks. Collectively, the

qualitative and quantitative findings paint a very clear picture of a community that is economically dependent on soapstone mining, greatly aware of its environmental consequences, and eager to participate in sustainability solutions. This is as long as the proposed efforts are inclusive, well-supported, and responsive to their lived realities.

Table 4.9: Thematic Analysis of Focus Group Discussions (FGDs)

Theme	Summary of Codes	Interpretation
Drivers of Soapstone Mining	Economic need, cultural heritage, skill transfer, lack of alternatives	Mining is sustained by economic dependency and inherited practices.
Perceived Benefits	Employment, income, education, infrastructure, tourism	Mining contributes significantly to local livelihoods and development.
Environmental Effects	Land degradation, water pollution, deforestation, poor waste disposal	Mining has adverse impacts on local ecosystems and landscapes.
Sustainability Challenges	Weak enforcement, lack of awareness, informal mining, low training	Environmental sustainability is constrained by poor regulation and knowledge gaps.
Strategies in Use	Community sensitisation, reforestation, local rules, NGO training	Grassroots efforts are being used but remain localised and sporadic.
Stakeholder Roles	County government, NEMA, community leaders, NGOs, miners	Participants favour participatory, community-led engagement over top-down oversight.
Recommendations	Policy enforcement, training, environmental monitoring, infrastructure support	Sustainable mining requires inclusive policymaking and tangible institutional support.

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter analyses the findings on environmental sustainability in Tabaka’s soapstone mining industry. It incorporates them with the research objectives discussed in this study. Looking at both quantitative and qualitative results from Chapter 4, it compares them with existing literature, addresses the environmental

effects, stakeholder roles, and sustainability strategies. This chapter also concludes with proposals for stakeholders and discusses ways in which research in the future can help reduce the existing scarce information on the subject at hand.

Environmental effects of the Soapstone Mining Industry

The study shows that soapstone mining in Tabaka leads to detrimental impact on the environment. It

reveals that quarry water accumulation was at (69.7%) and vegetation loss (55.5%) as the most prevalent effects. These findings are in line with prior studies in the Kenyan context indicating that quarrying activities do often lead to erosion of vegetation and deterioration of land. In recent studies for example, Barchok et al. (2024) documented an 18.24% decrease in vegetation cover in Narok between 2010 and 2022. This was linked to an increase in stone quarrying within the area (Barchok et al., 2024). Relatably, Abaho (2024) reported significant declines in plant diversity and rather increased soil erosion in Uganda's Kabale district that resulted from stone quarrying within the region (Abaho, 2024). Slightly moderate effects such as landscape alteration at (41.8%) and debris heaps at (41.3%) also correspond closely with reports by Omondi et al. (2022) in Kenya's Nyakach region, where quarrying led to soil loss and diminished land usability (Omondi et al., 2022). These presented comparisons support the conclusion that increased mass removal of rock and an overload in artisanal mining certainly disrupts physical landscape and visual appeal.

While water and noise pollution (both 14.8%) were less frequently reported, as well as garbage dumping (13.4%), these effects show similar documented concerns within quarries in Kiambu County where dust and runoff-related pollution affected vegetation health and community well-being, affecting up to 87.5% of plants and converting 70.8% of land into stagnant water bodies (Wangela & Shah, 2021). It has been proved in fact that the finding of water-filled quarries resonates with common consequences of abandoned pits that have been reported across Kenyan mining contexts (Maalim, 2022). The activity-based variation in perceptions where sculptors reported the highest average number of effects (2.42), followed by excavators (2.04) resonates with Rumbe (2021), whose research in Tabaka found that those who are closely associated and are involved in mining reported

more critical environmental degradation, including landslides, soil erosion, and siltation (Rumbe, 2021).

Although our one-way ANOVA rendered only marginal significance ($F = 7.62$, $p = 0.050$) in effect differences across activity groups, the trends presented are in line with the geological assessments in Kisii County that highlight slope disruption and safety risks at quarry sites that are poorly handled. Fredrick et al. (2023) stated that slope angles up to 69° and safety factors averaging 0.565 mean that quarry walls are unstable (Fredrick et al., 2023). As a result, this supports the study's observation that roles that are closer to quarry operations tend to perceive more environmental degradation. Collectively, the study's results confirm that the extent of environmental effects from soapstone mining in Tabaka is major and could be viewed as quite complex, particularly in terms of water related disruptions and vegetative degradation. The cross-study consistency enhances the credibility of the findings and highlights the urgent need for better policy interventions and sustainable quarry management strategies.

Role of stakeholders in promoting environmental sustainability

Stakeholder views in Tabaka portray a wide agreement in community participation and the need for sustainable policy frameworks as the major factors that would help towards the enhancement of environmental sustainability. This is in line with Machuma et al. (2022), who found that inclusive stakeholder engagement greatly enhances the sustainability of community initiatives in Kenya, and with Kibii and Ndolo (2021), who also highlighted that environmental compliance knowledge among quarry workers makes participatory mechanisms vital for improving regulation adherence.

It was revealed in the study that most sculptors (72.09%) were strongly in support for community participation. This reflects their daily closeness to

mining sites and is consistent with community-driven sustainability models in Kenyan contexts (Machuma et al., 2022). On the other hand, the preference among customers and traders for sustainable policies (61.22% and 57.69% respectively) aligns with Ochiai et al. (2022), who observed that value-chain actors in Ghana tended to favour formal governance mechanisms. Excavators' stronger support for quarry rehabilitation (23.08%) reflects reclamation priorities that have been identified in Kenyan mining surveys (Kibii & Ndolo, 2021).

Whereas the chi-square test found no statistically significant overall difference in strategy preferences ($\chi^2 = 35.62$, $p = 0.150$), the cross-tabulation in the data reveal significant role-specific emphases backing the argument by Kiio and Muna (2020) that stakeholders' lived experiences play an important role in shaping their sustainability preferences. Effective environmental governance in Tabaka will therefore need to accommodate both the broad consensus and the contextually specific priorities of different stakeholder groups.

Suitable environmental strategies

The study analysis demonstrates a strong consensus among stakeholders in Tabaka that community participation and sustainable policy frameworks are the most suitable environmental strategies for soapstone mining. This is in line with empirical evidence such as Mutu and Gachengo (2023), who stated that stakeholder participation greatly enhances performance of community water and development projects in Kirinyaga County (Mutu & Gachengo, 2023). Sculptors and other on-the-ground actors emphasized that community-driven approaches consistent with Karatina et al. (2022), which underscored that incorporating community participation, moderated by formal legal-political frameworks, helps in the support and promotion of long-term sustainability of development projects in Kenya (Karatina et al., 2022).

Similarly, high support for sustainable policies among value-chain actors echoes findings that regulatory frameworks are valued by stakeholders for ensuring environmental compliance and equity (Ochiai et al., 2022).

Support for quarry rehabilitation among excavators shows that their first-hand experience with ecological degradation, echoes international assessments that reclamation and restoration are very critical elements that are responsible for resource extraction (Kafu-Quvane et al., 2024). Additionally, involving stakeholders in co-created projects significantly improves accountability and uptake, as shown by Mganga et al. (2023) in community-based research initiatives underscoring the role of context-specific collaboration in sustainability outcomes (Mganga et al., 2023). Collectively, these findings suggest that effective environmental strategy for Tabaka's soapstone sector must work towards promoting inclusive stakeholder engagement, policy-driven regulations, and site rehabilitation.

Conclusions

Environmental effects of the Soapstone Mining Industry

Soapstone mining in Tabaka, Kisii County, throughout this study is strongly viewed as a major reason for negative environmental impacts. The accumulation of quarry water, vegetation loss, landscape alteration, and debris heaps are the most frequent effects portrayed in this study. These impacts collectively point to a constant negative change of the area's physical and ecological landscape. While effects such as water, noise pollution and garbage dumping were less frequent, their presence brings to light a bigger issue of regarding public health and sanitation concerns. The differences in occupations in reported effects with sculptors and excavators consistently observing more, suggests that the closeness to mining operations acts as an essential factor that shapes environmental experience. Therefore, without stronger enforcement of

environmental regulations and more responsible mining practices, these impacts are likely to become worse and greatly affect the existing pressures on natural resources and public health within the region.

The role of stakeholders in promoting environmental sustainability

It is very clear in this study that stakeholders across the soapstone mining sector share a very similar view of environmental sustainability needs, even where their specific priorities vary. The study shows that community members, sculptors, traders, customers, and county officials all agree to the fact that there is need for a range of stakeholder approaches that combine grassroots participation with institutional oversight. Currently, efforts by community groups and NGOs, though being of great importance, they remain fragmented and with limited resources. In order for there to be impactful progress, formal coordination between local actors and regulatory institutions, with roles that have been clearly defined and accountability mechanisms will be of essence. The evidence in this study therefore suggests that stakeholders are willing participants in sustainability efforts. What is largely missing however, is structured support and the enforcement capacity to make those efforts effective and sustained.

Suitable environmental strategies

Stakeholders in this study highlight both participatory approaches and regulatory frameworks as the major features to the achievement of long-term sustainability. In addition to this, the importance of institutions working in collaboration and the restoration of the environment is shaped by the specific roles and experiences of various actors within the mining ecosystem. These insights therefore point to the need for integrated, participatory frameworks that are responsive and beneficial to both community needs and environmental priorities. Incorporating environmental strategies with lived realities on the

ground fosters not only ecological resilience but also community togetherness and accountability. A participatory, policy-led design holds promise for transforming mining practices into more sustainable, equitable, and community-empowering processes in the region.

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