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Environmental and Socioeconomic Impacts of Mineral Exploitation on Fisheries in Imo State, Nigeria

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Abstract

This study examines the environmental and socioeconomic impacts of mineral exploitation on fisheries in Imo State, Nigeria. The region, rich in natural resources, experiences extensive mining activities that disrupt ecological systems and local livelihoods. Data were collected from 200 respondents in ten riverine communities using structured questionnaires and analyzed through descriptive statistics, weighted scoring, sentiment scoring, and Principal Component Analysis (PCA). The findings indicate that mining operations severely impact fisheries ecosystems, with habitat destruction (97.0%) and environmental pollution (93.0%) emerging as the most critical effects. Mining activities disrupt food chains, deplete groundwater levels, and cause erosion and siltation, leading to biodiversity loss and ecosystem instability. Socioeconomic challenges include the loss of farming and fishing livelihoods (99.0%), water scarcity (92.5%), health risks (86.5%), and forced migration (90.5%). Increased crime rates (78.0%) and resource strain further exacerbate the vulnerabilities of host communities. PCA analysis revealed that habitat destruction and pollution dominate the impacts, while localized effects like erosion remain significant. Despite these challenges, 94.5% of respondents acknowledged the existence of survival strategies, such as economic diversification and environmental restoration. This study highlights the urgent need for sustainable mining practices and inclusive policies to mitigate environmental damage and enhance community resilience. It offers actionable recommendations for balancing economic development with ecological preservation, contributing to global efforts to protect biodiversity and support livelihoods in resource-dependent regions.

Keywords: Biodiversity Loss, Habitat Destruction, Fisheries Degradation, Community Resilience, Socioeconomic Impacts, Mining Pollution.

Introduction

Nigeria is endowed with abundant solid natural resources, including limestone, granite, marble, gypsum, clay, tantalite, gold, coal, and gemstones, with over 44 mineral types found in commercial quantities across more than 500 locations throughout the country (Adegbite, 2021). Mineral extraction plays a pivotal role in the nation's economy, supplying raw materials for construction, agriculture, and other industries, while creating employment opportunities for laborers, technicians, and professionals (Hassan, 2022). In particular, Imo State in southeastern Nigeria is rich in crude oil, natural gas, lead, calcium

carbonate, gypsum, lignite, and zinc (Federal Ministry of Solid Minerals, 2022). The state's riverine communities are deeply reliant on their natural environment for fishing, farming, and commerce, which are integral to their livelihoods. Despite the economic benefits, mineral exploitation poses significant threats to ecosystems, biodiversity, and local livelihoods. Mining operations disrupt ecosystems through habitat destruction, pollution, and resource depletion. Deforestation and land excavation result in the loss of vital habitats, while toxic chemicals and heavy metals released during mining contaminate air, soil, and water, endangering both terrestrial and aquatic life (Adedeji et al., 2020; UNDP Nigeria, 2024). These disruptions are particularly impactful in riverine areas, where ecosystems play a critical role in supporting fisheries and agriculture, the primary occupations of the local population (Azevedo-Santos, et al., 2021). Furthermore, the noise from mining operations can interfere with wildlife communication, reproduction, and general well-being (Olden, et al., 2020).

Problem Statement

The fisheries ecosystem in Imo State's riverine areas has been severely affected by mineral mining. Fish populations, which are vital for food security and economic activities, have declined due to habitat destruction, contamination from mining byproducts, and changes in water flow and quality (Esheya, 2022). These disruptions also jeopardize the functional diversity of freshwater fish, which contribute to ecosystem services and support artisanal and commercial fisheries (Azevedo-Santos, et al., 2021). Large-scale fish kills and biodiversity loss resulting from toxic mine waste further exacerbate the challenges faced by these communities. Moreover, mineral exploitation negatively impacts the socioeconomic well-being of host communities. Pollution, loss of arable land, inadequate access to clean water, and displacement disrupt livelihoods, leading to tensions between mining companies and local populations. The lack of adequate benefits and community engagement has caused dissatisfaction and conflicts, further undermining the social fabric of these areas (Ojo, et al., 2018; Esheya, et al., 2022). Despite these challenges, little research has been conducted to systematically assess the impacts of mineral exploitation on fisheries ecosystems and local livelihoods in Imo State.

Objectives of the Study

This study aims to fill this knowledge gap by investigating the effects of mineral exploitation on *the environmental and socioeconomic impacts of mineral exploitation on fisheries in Imo State, Nigeria*. The specific objectives of this research include to:

i. assess the environmental, economic, and sociocultural impacts of mining on the host communities;
ii. identify the coping and survival mechanisms employed by affected populations; and
iii. provide insights to guide policymakers in formulating sustainable resource management and livelihood strategies.

This study contributes to a deeper understanding of the trade-offs between economic development and ecological preservation, offering actionable recommendations for balancing these priorities in mineral-rich regions.

Methodology

This study was conducted in Imo State, located in southeastern Nigeria, between latitudes 4°45′N and 7°15′N and longitudes 6°50′E and 7°25′E, covering approximately 5,100 square kilometers. Imo State is bordered by River Niger and Delta State to the west, Anambra State to the north, Rivers State to the south, and Abia State to the east (NPC, 2006). The population engages primarily in farming, fishing, and commerce, all of which are heavily influenced by the natural environment and mineral resource exploitation (Britannica, 2023). A quantitative research approach was adopted to examine the perceived sociocultural, environmental, and economic impacts of mineral exploitation on fisheries ecosystems and livelihoods in Imo State's riverine communities. The study utilized structured questionnaires and complementary analytical methods, including weighted scoring, sentiment scoring, principal component analysis (PCA), and descriptive statistics, to gain comprehensive insights into the research questions. Using Principal Component Analysis (PCA) with a sentiment scoring system is justified for dimensionality reduction, feature extraction, and improving model performance in sentiment analysis tasks, especially when dealing with large datasets and complex relationships between variable. PCA helps reduce the number of variables (features) in a dataset while retaining most of the original information. This is crucial in sentiment analysis where you might have many features that are not all equally important. The dimensionality is reduced but the data set still contains most of the information. In a nutshell, the idea of using PCA is to reduce the number of variables in a large data set while still preserving most of the information in exchange for losing little accuracy.

The study employed a systematic random sampling technique to select 200 respondents from 10 riverine settlements: Njaba, Orashi, Oguta, Utu, Awbana, Otamiri, Nworie, Onas, Umudi, and Okigwe. Twenty respondents were chosen from each settlement, ensuring representation from households directly affected by mineral exploitation. Each selected household provided a single respondent to represent all family members. Data for the study was gathered through oral interviews and a standardized questionnaire. Questionnaire validation ensures a tool measures what it intends, while ethical considerations prioritize participant rights and well-being during research. Key aspects include informed consent, confidentiality, and avoiding bias to ensure reliable and trustworthy research. Ethical considerations ensure the rights and well-being of respondents. Obtain informed consent by explaining the purpose and voluntary nature of participation. Protect data privacy through anonymization or confidentiality. Avoid coercive language and minimize respondent burden (Wesley, et al., 2015).

Results and Discussion

Table 1: Perceived Impact Analysis of Mineral Exploitation on Fisheries Ecosystem

Variable	Frequency	Percentage	Weight	Weighted_Score	Impact_Index	PCA_Component_1	PCA_Component_2
Destruction of natural habitat of fish and wildlife	194	97	5	970	0.219308162	32.58270481	8.92E-16
Environmental pollution and contamination	186	93	5	930	0.210264526	23.6384329	-8.17E-16
Noise disturbance	167	83.5	4	668	0.151028714	2.395787119	-3.78E-17
Alteration of food chains in the ecosystem	172	86	4	688	0.155550531	7.985957062	-1.25E-16
Depletion of groundwater levels	151	75.5	3	453	0.102419173	-15.4927567	-8.36E-17
Increased pressure on scarce natural resources	146	73	3	438	0.099027809	-21.08292664	-1.21E-16
Erosion and siltation	138	69	2	276	0.062401085	-30.02719855	4.17E-16

Source: Field Survey 2024.

Perceived Effects of Mineral Exploitation on Fisheries Ecosystems

Table 1 highlights the respondents' agreement on the perceived effects of mineral exploitation on fisheries ecosystems in riverine areas. The majority identified key impacts, including destruction of natural habitats (97.0%), environmental pollution (93.0%), noise disturbance (83.5%), alteration of food chains (86.0%), depletion of groundwater levels (75.5%), increased pressure on scarce natural resources (73.0%), and erosion/siltation (69.0%). Mining alters terrain and removes vegetation, leading to habitat loss for numerous species. This disrupts microclimates, forces wildlife migration, and risks ecosystem imbalances due to the introduction of new predators or competitors (MAJR Resources, 2024). Pollutants such as heavy metals, acids, and chemical wastes disrupt ecosystems, with contaminants accumulating in the food chain. Aquatic species are particularly vulnerable, experiencing reduced reproduction, mutations, and mortality. Sedimentation also degrades coral reefs, critical habitats for marine life (Esheya, 2021).

Mining noise disrupts wildlife behaviors such as communication and mating, causing stress and habitat abandonment. Prolonged exposure can lead to hearing loss in animals, impairing their ability to detect predators and maintain social interactions (Ndinwa and Ohwone, 2014; Wesley, et al., 2015). Mining eliminates vegetation, disrupting herbivores' food sources and cascading up the food chain. Pollutants cause toxicity and disease in wildlife, destabilizing ecosystems (Scharnweber, et al., 2024). Mining reduces water availability, impacting aquatic species and fragmenting ecosystems. Drying wetlands and changes in water tables further reduce biodiversity (Idris-Nda, et al., 2018). Erosion introduces contaminants, affecting fish physiology and reducing habitat quality, further degrading ecosystems (Lopes, et al., 2019).

Furthermore, the table 1 presents the perceived effects of mineral exploitation on fisheries ecosystems, analyzed using a weighted scoring method and normalized to produce an **Impact Index**. The results indicate the relative significance of each variable in terms of its

impact on the ecosystem. The findings of the study highlight that the most significant perceived impacts of mineral exploitation on fisheries ecosystems are **destruction of natural habitat** and **environmental pollution and contamination,** which had the highest Impact Index scores. Habitat destruction is particularly critical, as it leads to the displacement of species, loss of biodiversity, and disruption of ecological balance. Similarly, pollution from toxic waste, chemical runoff, and sedimentation adversely affects water quality, aquatic species' survival, and reproductive processes.

These findings align closely with existing literature on the environmental impacts of mineral exploitation. For instance, Azevedo-Santos et al. (2021) reported that mining activities significantly degrade freshwater ecosystems, leading to biodiversity loss and disruption of critical ecological services. Similarly, Lynch et al. (2016) highlighted the cascading impacts of pollution on food chains, documenting how contaminants disrupt predator-prey dynamics and fish diversity. The study also found that alteration of food chains and noise disturbance are prominent secondary impacts, reflecting the cascading effects of ecological disruption and stress caused by mining operations. This is consistent with observations by Olden et al. (2020), who noted that mining-induced disturbances alter ecosystem structures and reduce species interactions, further exacerbating environmental degradation. These findings resonate with studies like Adedeji et al. (2020), which highlighted erosion and sedimentation as critical issues in riverine ecosystems, affecting water flow, fish habitats, and soil stability. The integration of these findings into existing research emphasizes the need for holistic, sustainable mining practices that address both primary and secondary impacts. This study reinforces global calls, such as those by UNDP Nigeria (2024), for stricter regulatory measures and ecosystem-based management approaches to mitigate the detrimental effects of mineral exploitation on fisheries ecosystems.

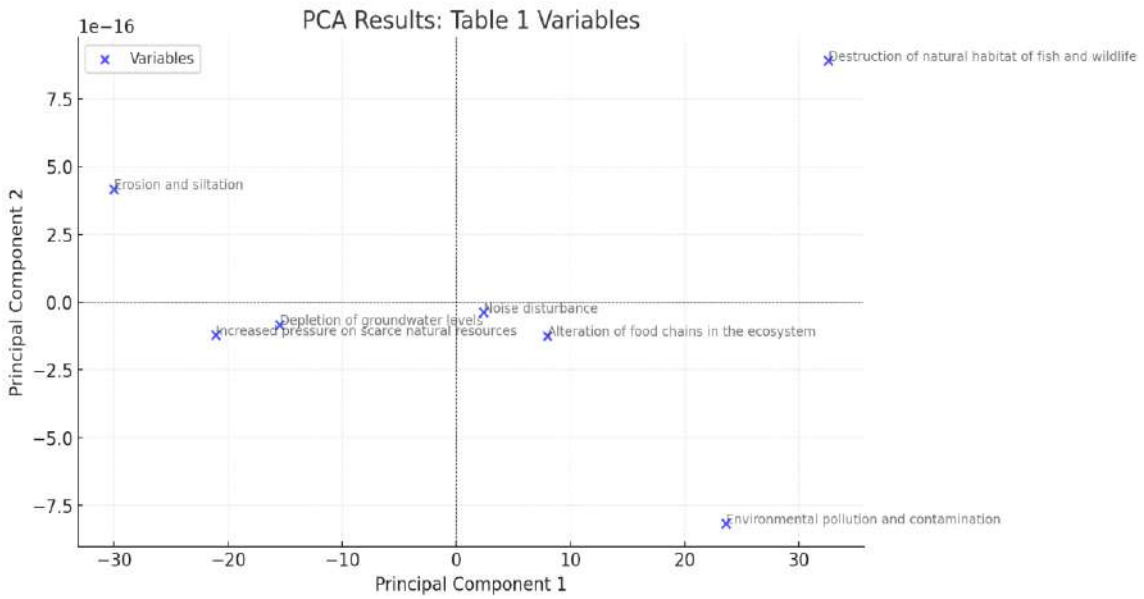


Figure 1: Principal Component Analysis Visualization of Fisheries Ecosystem Impact Variables

Principal Component Analysis Visualization of Fisheries Ecosystem Impact Variables

The Principal Component Analysis (PCA) revealed two primary components representing the perceived impacts of mineral exploitation on fisheries ecosystems. Principal Component 1 (PC1), which captured the overall intensity and prevalence of impacts, showed strong associations with variables such as destruction of natural habitat of fish and wildlife and environmental pollution and contamination. This indicates that these are the most dominant and universally recognized issues across respondents. Principal Component 2 (PC2), on the other hand, highlighted differences in localized impacts, such as erosion and siltation, emphasizing the context-specific nature of certain effects. The PCA visualization demonstrated clustering among variables like destruction of habitat, alteration of food chains, and environmental pollution, suggesting their interrelated nature in disrupting ecological balance. This clustering aligns with findings from Azevedo-Santos et al. (2021), who documented the intertwined effects of pollution, habitat loss, and biodiversity decline in freshwater ecosystems. Similarly, Lynch et al. (2016) emphasized that the interconnectedness of these impacts can have cascading effects on food webs and ecosystem services.

The separation of variables such as erosion and siltation in the PCA space reflects their unique, localized significance. While these impacts were ranked lower in other analyses, their distinction in the PCA highlights the need for tailored interventions to address site-specific challenges. This finding supports studies like Adedeji et al. (2020), which identified erosion and sedimentation as critical but often overlooked issues that can severely impact aquatic ecosystems. This aligns with the broader consensus in the literature, such as Olden et al. (2020) and UNDP Nigeria (2024), which advocate for multidimensional approaches to environmental management. The PCA visualization not only corroborates the dominance of habitat destruction and pollution but also highlights the importance of addressing secondary and localized impacts.

Table 2: Perceived Impact of Mineral Exploitation on the Livelihood of the Host Communities

Variable	Frequency	Percentage	Weight	Weighted_ Score	Impact_ Index	PCA Component 1	PCA Component 2
Climate change	145	72.5	3	435	0.08213746	-22.609132	3.24E-15
Loss of farming and fishing occupation	198	99	5	990	0.18693353	36.6466696	4.38E-16
Susceptibility to health risks	173	86.5	4	692	0.13066465	8.69581991	4.21E-16
Forced displacement and migration	181	90.5	4	724	0.13670695	17.6400918	7.56E-16
Frequent outbreak of civil crisis	164	82	3	492	0.0929003	-1.366486	-1.66E-17
Increased crime rate	156	78	3	468	0.08836858	-10.310758	-2.30E-16
Strain on local infrastructure	147	73.5	2	294	0.0555136	-20.373064	-5.47E-16
Scarcity and poor access to clean water	185	92.5	5	925	0.17466012	22.1122278	6.81E-16
Negative publicity	138	69	2	276	0.0521148	-30.43537	-3.79E-16

Source: Field Survey 2024.

Impact of Mineral Exploitation on the Livelihood of the Host Communities

Mineral mining significantly affects riverine host communities, impacting their environment, economy, and social structures. The findings of this study highlight critical issues stemming from these activities and their broader implications. According to the results in Table 2, 145 respondents (72.5%) reported that climate change induced by mining operations negatively affects their livelihoods. Heavy emissions from fuel combustion in quarries and processing facilities contribute to global warming through the greenhouse effect, disrupting natural vegetation and reducing crop productivity (Oshim, et al., 2024). These effects exacerbate the vulnerability of communities that depend on agriculture. Rising sea levels, a byproduct of climate change, further threaten these regions.

A majority of respondents, 198 (99.0%), identified the loss of stable income sources, such as farming and fishing, as a major consequence of mining. Mining activities degrade soil fertility through chemical contamination, rendering land unsuitable for agriculture. Additionally, deforestation, often undertaken to clear mining sites, leads to soil erosion and the loss of habitats for wildlife, further destabilizing ecosystems (Mathew and Suleiman, 2022). Water pollution caused by mining activities harms aquatic ecosystems, contributing to a decline in fish populations. This decline affects fishing-dependent industries, leading to financial losses, job insecurity, and reduced economic activity (Bahloul, et al., 2024).

Health risks were also a prominent concern, cited by 173 respondents (86.5%). Mining-related pollutants, including hazardous chemicals and heavy metals, pose serious health threats, including terminal illnesses. Consuming contaminated fish exacerbates health risks and reduces fishing participation, eroding cultural and recreational traditions tied to river ecosystems. These health challenges weaken the community's relationship with natural resources and further destabilize livelihoods (Shiquan, et al., 2022).

Social disruptions, such as forced displacement and migration, were noted by 181 respondents (90.5%). Mining projects often require large-scale land acquisition, displacing individuals and communities. This process disrupts social structures, leading to the loss of homes, farmlands, and cultural ties. Environmental degradation caused by mining frequently renders areas uninhabitable, forcing communities to relocate (Oshim, et al., 2024). This displacement not only undermines social cohesion but also increases economic instability for the affected populations. Additional social impacts include increased crime rates (166 respondents, 78.0%), strain on local infrastructure (147 respondents, 73.5%), and frequent civil crises. The influx of laborers associated with mining activities introduces new social vices, including crime, drug abuse, and prostitution, while also straining local resources (Esheya, 2012). These issues exacerbate tensions between mining companies and host communities, often culminating in disputes over resource distribution and decision-making processes (Mabe, et al., 2022). Water scarcity emerged as a critical challenge, highlighted by 185 respondents (92.5%). Mining activities contaminate water sources through acid mine drainage (AMD) and heavy metal seepage, making water unsafe for consumption and aquatic life (Rock, 2024). Lowering of the water table due to mining exacerbates water scarcity, negatively impacting agriculture, fisheries, and biodiversity.

This degradation of water resources not only affects human and ecological health but also reduces community resilience. The environmental degradation caused by mining operations often results in negative publicity for affected regions, cited by 138 respondents (69.0%). Such unfavorable attention discourages tourism and investment, further harming local economies (Esheya, 2021). Mining's impacts on the environment, including deforestation, soil erosion, and water pollution, reduce the sustainability of ecosystems and undermine long-term economic development (Umar and Oriri, 2023). These findings align with global research on the socio-economic and environmental impacts of mining.

Lynch et al. (2016) documented how environmental degradation disrupts social and economic systems, while Azevedo-Santos et al. (2021) highlighted the cascading effects of water pollution and biodiversity loss in mining regions. Mining disproportionately harms vulnerable communities, particularly in developing nations with limited institutional frameworks for resource management (Adebayo, 2023). The weighted scoring method quantified the severity of perceived impacts on livelihoods due to mineral exploitation. The findings of this study reveal that the loss of farming and fishing occupations and scarcity of clean water are the most significant impacts of mineral exploitation on the livelihoods of host communities. These results, derived from the highest Impact Index scores, highlight the critical dependence of riverine communities on agriculture, fisheries, and water resources for their sustenance and economic well-being. The loss of these resources due to land degradation, pollution, and resource depletion underscores the far-reaching implications of mineral exploitation. This aligns with findings from Adedeji et al. (2020), who emphasized the adverse effects of mining on arable land and freshwater resources, which directly disrupt traditional livelihoods in rural communities.

Similarly, Azevedo-Santos et al. (2021) reported the severe impact of mining activities on water quality, leading to resource scarcity and ecosystem degradation, particularly in biodiversity-rich areas. Secondary impacts, such as forced displacement and migration and susceptibility to health risks, were also identified as significant but less dominant concerns. These issues reflect the social and health vulnerabilities that arise when communities are uprooted or exposed to hazardous environmental conditions. The Principal Component Analysis (PCA) further reinforced these patterns, with the first principal component (PC1) capturing the dominant livelihood impacts (e.g., loss of farming and water scarcity). These variables were closely clustered in the PCA visualization, indicating their interconnected nature. This finding resonates with Lynch et al. (2016), who documented the cascading effects of environmental degradation on local economies and food security. The second principal component (PC2) highlighted localized and less immediate impacts, such as negative publicity and strain on infrastructure, reflecting the broader but context-dependent repercussions of mineral exploitation.

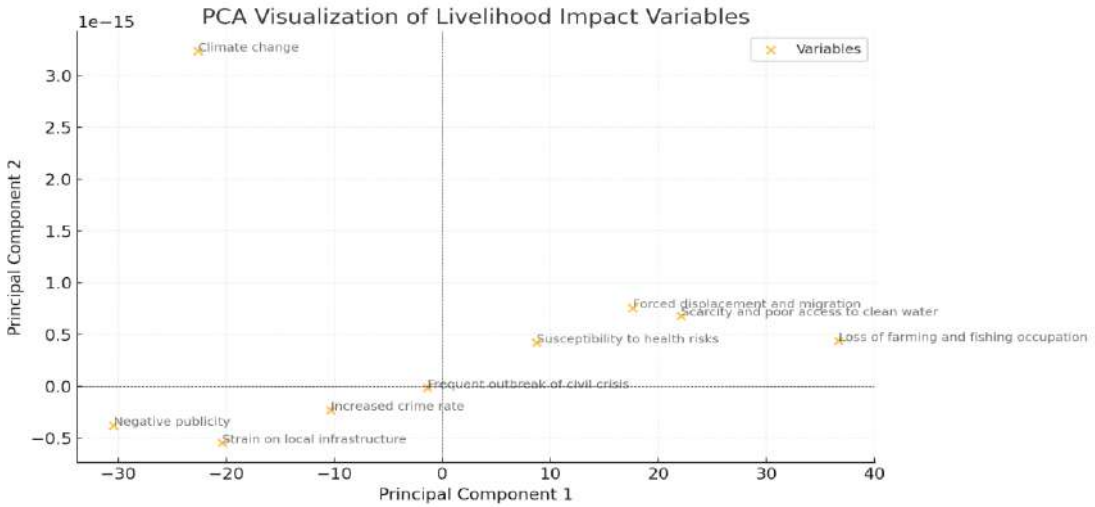


Figure 2: Principal Component Analysis Visualization of Livelihood Impact Variables

Existence of Survival/Coping Strategies in Mineral Mining Riverine Host Communities

Response	Frequency	Weight	Weighted Score	Normalized Score	Sentiment Value	Sentiment Score	%
Agree	189	5	945	0.982328482	1	189	94.5
Disagree	8	1	8	0.008316008	-1	-8	4
Undecided	3	3	9	0.009355509	0	0	1.5

Source: Field Survey 2024.

Perception of Survival and Coping Strategies in Riverine Communities

According to the results in Table 3, 189 respondents (94.5%) confirmed that residents whose livelihoods were affected by mineral mining in the riverine zones of Imo State employed various survival and coping strategies. However, 3 respondents (1.5%) expressed uncertainty about the effectiveness of these alternatives, while 8 respondents (4.0%) disagreed. The substantial impact of mineral mining on riverine host communities, particularly on livelihoods, health, and the environment, is evident. To mitigate these negative effects and support the affected populations, several coping and survival strategies have been identified (Mabe, et al., 2023).

As shown in Table 4, these strategies should prioritize economic diversification, environmental protection, sustainable development, and health improvement. The analysis of community perceptions regarding survival and coping strategies in riverine areas affected by mineral exploitation reveals a predominantly positive outlook. Using weighted scoring, sentiment scoring, and descriptive analysis, the findings provide valuable insights into community resilience and adaptation. The weighted scoring analysis shows that "Agree" responses dominate, with the highest weighted and normalized scores. This indicates strong confidence among the majority of respondents in the existence and effectiveness of survival and coping strategies. The lower weighted scores for "Disagree" and "Undecided" responses reflect minimal skepticism or uncertainty, suggesting that such

strategies are widely recognized and accepted. This confidence is likely a result of tangible benefits observed or experienced by the community members from these measures. In the sentiment scoring analysis, responses were assigned sentiment values (+1 for "Agree," 0 for "Undecided," and -1 for "Disagree"), resulting in an overall sentiment score of 181. This score underscores the overwhelmingly positive sentiment of the community, driven by a substantial proportion of "Agree" responses. The negligible negative sentiment arising from "Disagree" responses further reinforces the community's optimistic view of survival strategies.

The descriptive analysis supports these findings, with 94.5% of respondents agreeing on the existence of survival strategies, while only 4% expressed disagreement and 1.5% were undecided. This distribution highlights a strong consensus among the community while identifying a small subset that may require targeted engagement to address their concerns or uncertainties. These results align with existing research on community resilience and adaptive strategies in mining-affected regions. Studies such as Azevedo-Santos et al. (2021) emphasize the importance of community-based strategies in mitigating the socio-economic impacts of resource extraction, particularly in riverine and biodiversity-rich areas. Similarly, Lynch et al. (2016) note the critical role of adaptive measures in maintaining livelihoods and enhancing community well-being amidst environmental and economic challenges. The overwhelmingly positive sentiment in this study reflects the efficacy of such strategies in fostering resilience, mirroring the conclusions of these global studies. However, the small subset of dissenting or undecided respondents underscores challenges also noted in the literature, such as the need for inclusivity and equitable benefit-sharing in community adaptation efforts (Olden, et al., 2020). Addressing these concerns through improved communication, broader engagement, and equitable resource distribution can strengthen overall community support for survival strategies. The findings highlight a strong positive perception of survival and coping strategies among respondents, with 94.5% agreeing on their existence and an overall sentiment score of 181. These results demonstrate the community's confidence in its resilience, aligning with global studies on the effectiveness of adaptive strategies in mining-affected regions. However, the 4% dissent and 1.5% uncertainty emphasize the need for more inclusive and communicative approaches to ensure comprehensive community participation.

Conclusion and Recommendations

In addition to causing significant environmental and ecosystem disruptions, mineral exploitation activities harm the wellbeing of nearby communities by spreading pollution and causing financial losses. Mining operations have had varying effects on the diversity of fish ecosystems. The high environmental and health costs of mineral exploration, processing, and transportation, among other things, significantly limit investments in Nigerian mining exploration and exploitation. The current exploitation techniques and technologies aid in the competition for the accessible forests, rich land, and ground and surface water supplies. The livelihood of the riverine mining host communities is impacted by a number of environmental and socioeconomic issues brought on by mineral

exploitation. These issues include the loss of farming and fishing occupation, vulnerability to health risks, forced migration or displacement, frequent civil crises, an increase in crime, stress on local infrastructure, limited or poor access to clean water, and bad publicity for the affected areas. However, this study faced some limitations. Sometimes limitations arise from tangible circumstances like time and funding constraints, or equipment and participant availability. Other times the rationale is more obscure and buried within the research design.

In order to increase efficiency and lessen the detrimental effects of mineral exploitation on the standard of living of riverine mining host communities in the study area, this paper suggests the adoption of sustainable mineral exploitation practices, the use of cutting-edge technologies, policies, and regulatory frameworks. In order to lessen the detrimental environmental effects of mining in these areas, the Mineral Agency, the Imo State Environmental Protection Agency, and other relevant authorities/institutions should enhance their monitoring efforts and implement regulatory standards.

Conflicts of Interest

The authors hereby declare not conflicts of interest.

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