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INTEGRATION OF EIA IN PROPOSING STRATEGIC MITIGATION MEASURES TO REDUCE THE ENVIRONMENTAL IMPACT OF MINING IN PAKISTAN IN 2025

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ABSTRACT

Mining is a critical sector for Pakistan's economic development, providing essential resources and contributing significantly to GDP. However, mining activities also pose substantial environmental and socio-economic challenges. This Environmental Impact Assessment (EIA) evaluates the environmental impacts of mining in Pakistan and proposes actionable mitigation measures to promote sustainable practices. The EIA process has identified several significant environmental impacts associated with mining activities in Pakistan, which vary in severity depending on the type and scale of the operation. One of the primary concerns is air pollution, where mining operations contribute to the degradation of air quality, primarily due to dust emissions and gaseous pollutants. Areas near large-scale operations, such as coal mines in Thar, experience elevated levels of particulate matter, posing health risks to local populations. Water pollution is another major issue, with the discharge of untreated wastewater, especially from coal and marble mining in regions like Balochistan, leading to contamination of nearby water bodies with heavy metals and acid mine drainage (AMD). Soil degradation **is** also prevalent, as mining activities, particularly those involving surface mining, result in the loss of topsoil, erosion, and degradation of agricultural land. Biodiversity losshas been noted as a significant consequence of habitat destruction and fragmentation, leading to the decline of species in affected areas, such as the loss of forest cover and disruption of wildlife corridors in provinces like Khyber Pakhtunkhwa. Lastly, socio-economic impacts, including the displacement of communities, loss of livelihoods, and disruption of local economies, have been raised during public consultations. These impacts have led to increased socio-economic inequalities in some mining regions, highlighting the need for mitigation and sustainable practices.

KEY WORDS: Environmental Impact; Mining; Pakistan; Pollution; Mitigation.

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INTRODUCTION

Mining is an essential industrial activity that involves the extraction of minerals and resources from the earth's crust [1]. In Pakistan, mining is a vital sector contributing significantly to the national economy. However, mining operations often lead to environmental challenges, including land degradation, water pollution, and habitat destruction [2]. This article aims to assess these impacts comprehensively and propose mitigation measures to ensure sustainable practices.

Figure 1: Land Mining in Pakistan

Overview of Mining Activities in Pakistan

Pakistan is endowed with a variety of mineral resources, including coal, gold, copper, limestone, and gypsum, which are scattered across its provinces [3]. Key mining areas include the Saindak Copper-Gold Project in Balochistan, coal reserves in Sindh's Thar region, and the salt mines of Punjab [4]. The mining sector in Pakistan not only provides raw materials for industries but also creates employment opportunities for thousands of people [5]. However, most mining practices in Pakistan rely on outdated methods that lack environmental safeguards, leading to significant ecological consequences [6].

Importance of Mining to the Economy and Development

The mining sector contributes approximately 2.5% to Pakistan's GDP and plays a critical role in driving industrial growth [7]. Minerals such as coal and limestone are pivotal for the energy and construction sectors, respectively, while precious metals and gemstones contribute to foreign exchange earnings [8]. Despite its economic importance, the environmental costs associated with mining, including deforestation, soil erosion, and water contamination, pose a significant challenge to achieving sustainable development in Pakistan [9]

Figure 2: Importance of Land Mining to the Economy of Pakistan

To Assess the Environmental Impact of Mining in Pakistan

Mining activities, though economically beneficial, often result in severe environmental impacts. These include the generation of hazardous waste, biodiversity loss, and contamination of water bodies through acid mine drainage [10]. This article aims to evaluate these impacts through the lens of various mining operations across Pakistan, identifying key areas of concern and their underlying causes [11].

To Propose Measures to Mitigate Negative Effects

A core objective of this article is to recommend strategies to reduce the adverse environmental effects of mining. Measures such as the adoption of modern technologies, strict regulatory frameworks, and rehabilitation of mined areas will be discussed to align mining practices with principles of sustainability [12].

Relevance of Environmental Impact Assessment (EIA)

Importance of EIA in Sustainable Mining Practices

Environmental Impact Assessment (EIA) serves as a crucial tool for evaluating the potential environmental impacts of mining projects before they are initiated [13]. It ensures that mining activities are planned with environmental safeguards to prevent long-term damage [14]. In Pakistan, the enforcement of EIA laws, such as those outlined in the Pakistan Environmental Protection Act of 1997, is essential for promoting responsible mining practices [15]. Effective EIAs can guide policymakers in balancing economic benefits with environmental conservation, thereby ensuring sustainable development [16].

Scope Geographic Focus, Specific Mining Activities, and Environmental Parameters Considered

This research will focus on mining activities in key regions such as Balochistan, Sindh, and Punjab, examining operations ranging from large-scale coal mining to small-scale gemstone extraction. The environmental parameters under consideration include air and water quality, biodiversity loss, soil degradation, and the socio-economic impacts on local communities. By narrowing the scope to these specific aspects, the study aims to provide a detailed and actionable analysis of the environmental impacts of mining in Pakistan.

Methodology

The methodology for this study is designed to systematically evaluate the environmental impacts of mining in Pakistan and propose effective mitigation measures. It involves a combination of primary and secondary data collection techniques, supported by advanced tools and technologies for data analysis and visualization [17].

Data Collection

Primary Data: Site Visits and Surveys

Primary data collection is a critical component of this study, involving direct observations and surveys conducted at mining sites in key regions such as Balochistan, Sindh, and Punjab [18]. Site visits allow for the firsthand assessment of environmental conditions, including air quality, water contamination, and the extent of land degradation [19]. Surveys conducted with local communities, miners, and environmental experts provide qualitative insights into the socio-economic and ecological impacts of mining [20]. These interactions help identify localized issues and the perspectives of stakeholders on sustainable mining practices [21].

Secondary Data: Literature Review and Government Reports

Secondary data sources include a comprehensive review of existing literature, government reports, and international case studies related to mining and environmental impact [22]. Key documents, such as the Pakistan Environmental Protection Agency's reports and regional environmental assessments, are analyzed to establish a baseline of knowledge and compare global best practices [23]. Peer-reviewed articles, environmental impact assessments (EIAs) of mining projects, and data from organizations like the International Council on Mining and Metals (ICMM) are also referenced to provide a broader context for the study [24].

Tools and Techniques

Environmental Modeling Tools

Environmental modeling tools are utilized to simulate and predict the impacts of mining activities on air, water, and soil quality [25]. These tools help in quantifying emissions, understanding the dispersion of pollutants, and assessing the effectiveness of mitigation measures [26]. For instance, models like AERMOD and CALPUFF are employed for air quality analysis, while AQUATOX is used to evaluate aquatic ecosystem impacts [27, 28].

Geographic Information System (GIS) and Remote Sensing

GIS and remote sensing technologies play a pivotal role in the spatial analysis of mining impacts [29]. GIS is used to map and analyze land use changes, deforestation, and habitat loss in mining regions, providing a visual representation of environmental degradation [30]. Remote sensing data from satellite imagery helps monitor changes in surface conditions over time, offering insights into long-term trends caused by mining activities [31]. Together, these tools enable a comprehensive evaluation of the spatial and temporal impacts of mining operations [32].

Screening

Screening is the initial step in the Environmental Impact Assessment (EIA) process, designed to determine whether a proposed mining project requires a full EIA or if it can proceed with a simpler environmental assessment [33]. This stage is crucial for efficiently allocating resources and focusing efforts on projects with significant environmental impacts [34]. By applying specific criteria, authorities can quickly identify projects that pose a substantial risk to the environment and require detailed evaluation [35].For mining projects, screening helps in identifying operations that might lead to adverse effects, such as habitat destruction, water contamination, or air pollution [36]. This step minimizes delays and prevents unnecessary resource expenditure on low-impact projects, ensuring that environmental concerns are addressed early in the project lifecycle [37].

Criteria Used for Screening

- **Scale and Type of Mining Activity**

  One of the primary screening criteria is the scale and type of mining activity. Large-scale mining operations, such as open-pit mining and extensive coal extraction, typically have a higher environmental footprint compared to small-scale or artisanal mining [38]. The intensity of land use, volume of extracted material, and generation of waste are key factors influencing this criterion [39]. For instance, large-scale operations often involve significant deforestation and water usage, necessitating a full EIA to evaluate their impact comprehensively [40].

- **Potential Impact on Sensitive Areas**
  Another critical criterion is the proximity of the mining activity to environmentally sensitive areas. These include protected ecosystems, such as national parks, wetlands, and biodiversity hotspots, as well as vital water bodies and communities dependent on natural resources [41]. Mining projects near such areas are more likely to disrupt ecological balance, endanger wildlife, or harm local livelihoods [42]. For example, mining in Balochistan's Reko Diq region, known for its unique biodiversity, demands stringent screening to prevent irreparable damage to the environment [43].

The screening process concludes with a decision on whether a full EIA is required. If the project is deemed to have minimal environmental risks, it may proceed with a simpler environmental management plan [44]. However, if the screening reveals significant potential impacts, a detailed EIA is mandated to evaluate and mitigate these risks [45]. This outcome ensures that high-risk projects are subject to rigorous scrutiny, fostering sustainable mining practices while safeguarding the environment [46].

Maps of mining areas
Maps are essential for visually representing the geographic scope of mining operations and the areas impacted by such activities. These maps typically include locations of mining sites, surrounding infrastructure, protected ecosystems, and nearby water bodies [47]. Maps help in identifying spatial patterns of environmental degradation and are critical in the scoping phase of the EIA [48].

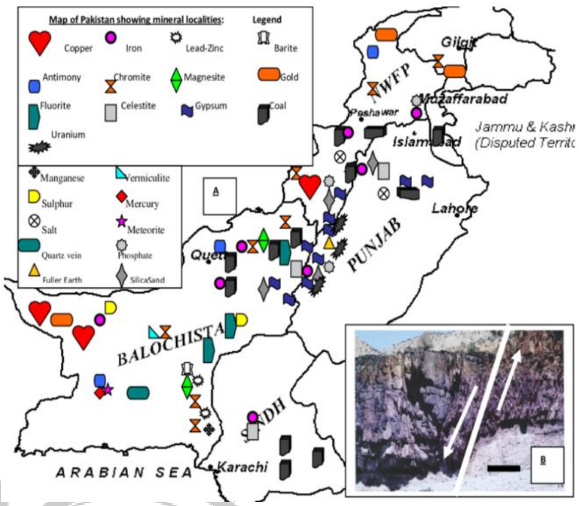

Figure 3:Map of Pakistan showing mineral localities; Dilband iron ore

Scoping
Scoping is a critical stage in the Environmental Impact Assessment (EIA) process, aimed at defining the scope and depth of the assessment. It identifies the key environmental issues, potential impacts, and areas of focus that need detailed examination [49]. Scoping ensures that the EIA is both comprehensive and efficient, addressing the most significant concerns while avoiding unnecessary evaluations of less critical aspects [50].

Purpose of Scoping
The primary purpose of scoping is to streamline the EIA process by identifying the key environmental issues associated with a mining project [51]. This step ensures that the assessment is focused on significant impacts, such as water contamination, habitat destruction, or air pollution, rather than on trivial concerns [52]. By prioritizing critical areas, scoping reduces the time and cost of the EIA while ensuring that all potential risks are adequately addressed [53]. For instance, in large-scale mining operations like the Thar Coal Project in Sindh, scoping helps in pinpointing specific risks such as groundwater depletion and air quality deterioration [54].

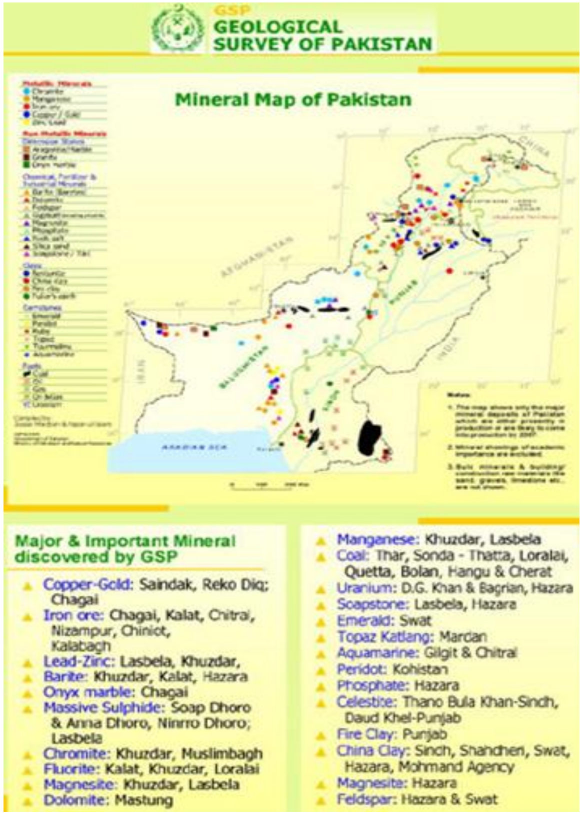

Figure 4:Mineral and energy resources data from Geological survey of Pakistan

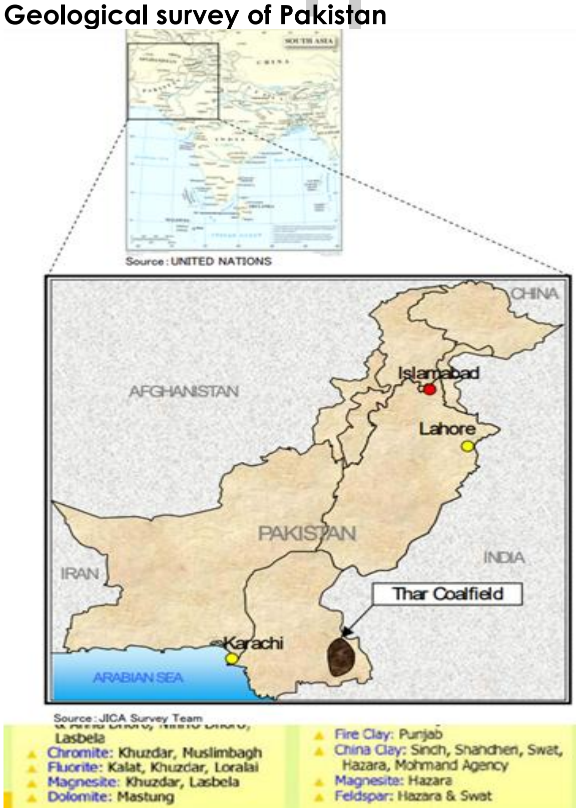

Figure 5:Coal Mining Operations in Thar, Pakistan

Stakeholder Consultation

Scoping involves consulting a wide range of stakeholders to gather diverse perspectives and concerns related to the proposed mining project [55]. Key stakeholders include:

- **Government Agencies**: Regulatory bodies, such as the Pakistan Environmental Protection Agency (Pak-EPA), provide guidance on compliance with national and provincial environmental laws [56].
- **Non-Governmental Organizations (NGOs)**: Environmental and advocacy groups contribute expertise on ecological preservation and community rights [57].
- **Local Communities**: Residents of the areas affected by mining are vital stakeholders, as they often bear the brunt of environmental degradation. Their input is crucial for understanding localized impacts and identifying culturally sensitive issues [58].
- **Industry Experts and Academics**: Specialists in mining, environmental science, and public health provide technical insights into the potential risks and mitigation strategies [59].

Stakeholder engagement ensures a participatory approach, fostering transparency and inclusivity in the scoping process [60]. For example, involving local communities in Balochistan's mining projects highlights socio-economic impacts such as displacement and livelihood disruption [61].

Environmental Parameters Identified

The scoping process identifies specific environmental parameters that need detailed analysis in the EIA. These parameters include:

- **Air Quality**: Dust and emissions from mining operations and associated transportation activities are assessed for their impact on respiratory health and climate [62].
- **Water Quality**: Mining can lead to the contamination of surface and groundwater through acid mine drainage and chemical leaks. Monitoring water quality is essential to protect aquatic ecosystems and local water supplies [63].
- **Soil Degradation**: Mining activities often lead to soil erosion, nutrient depletion, and contamination, affecting agricultural productivity and ecosystem stability [64].
- **Deforestation**: Clearing land for mining operations can result in significant loss of forest cover, impacting carbon sequestration and local biodiversity [65].
- **Biodiversity Loss**: Habitat destruction and pollution from mining pose severe risks to flora and fauna, especially in ecologically sensitive regions [66].

By focusing on these parameters, scoping ensures that the EIA addresses the most pressing environmental concerns comprehensively.

Impact Analysis

Impact analysis is a core component of the Environmental Impact Assessment (EIA) process, aiming to evaluate the potential environmental and socio-economic effects of mining activities. This stage identifies and assesses the extent, severity, and duration of impacts, providing the foundation for mitigation strategies and sustainable practices [67].

Identification of Impacts

- **Short-Term and Long-Term Impacts:** Short-term impacts of mining often include immediate effects such as dust emissions, noise pollution, and temporary displacement of local communities during the initial stages of excavation [68]. These impacts, while transient, can cause significant disruptions to local ecosystems and human activities [69]. Long-term impacts, on the other hand, are more profound and persistent. These include soil degradation, groundwater depletion, biodiversity loss, and health issues arising from prolonged exposure to pollutants [70]. For instance, coal mining in the Thar Desert has led to both immediate habitat disruption and long-term water resource challenges [71].
- **Direct, Indirect, and Cumulative Impacts:**

1. **Direct Impacts**: These are immediate and localized effects, such as land clearing and habitat destruction at the mining site [72].
2. **Indirect Impacts**: Indirect effects stem from activities associated with mining, such as transportation and industrial processing, which can lead to secondary pollution in nearby areas [73].
3. **Cumulative Impacts**: These arise when multiple mining operations or prolonged activities in a region amplify environmental degradation. For example, continuous marble mining in Balochistan has cumulatively affected soil stability and water quality over decades [74].

Assessment Methods

Use of Qualitative and Quantitative Techniques

Impact analysis employs a combination of qualitative and quantitative methods to ensure a comprehensive evaluation [75]:

- **Qualitative Techniques**: Stakeholder interviews, field observations, and descriptive analyses help capture the socio-economic and ecological effects of mining [76].
- **Quantitative Techniques**: Data from air and water quality monitoring, soil testing, and biodiversity surveys are analyzed using statistical and environmental modeling tools [77]. For instance, Geographic Information System (GIS) tools are used to map land use changes, while air quality models like AERMOD predict pollutant dispersion [78].

These methods together provide a holistic understanding of the scale and scope of mining impacts [79].

Impacts on Environmental Parameters

- **Air Quality**: Mining operations release particulate matter (PM), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) into the atmosphere, contributing to respiratory issues and climate change [80]. For example, coal mining in Thar has been linked to increased PM concentrations in nearby settlements [81].
- **Water Resources**: Acid mine drainage (AMD) and chemical spills contaminate surface and groundwater, impacting both ecosystems and local water supplies. Mining in the Saindak region of Balochistan has raised concerns about heavy metal contamination in nearby water bodies [82].
- **Soil Degradation**: Mining activities strip the land of topsoil, reducing its fertility and making it prone to erosion [83]. Limestone and marble mining in Punjab have left large tracts of degraded land unsuitable for agriculture [84].
- **Biodiversity Loss**: Habitat destruction due to deforestation and pollution disrupts ecosystems, threatening species survival [85]. Mining in protected areas near Margalla Hills has severely impacted local flora and fauna [86].

Socio-Economic Impacts

Mining activities displace communities, disrupt traditional livelihoods, and expose local populations to health risks [87]. In the Thar region, while coal mining has created jobs, it has also led to the relocation of indigenous communities and increased water scarcity [88].

Examples

- **Coal Mining in Thar**: This project has provided energy resources but has caused significant groundwater depletion, air pollution, and community displacement [89].
- **Marble Mining in Balochistan**: The extraction of marble has caused deforestation, water contamination, and reduced soil stability, impacting both the environment and local agriculture [90].

Mitigation Measures

Mitigation measures are essential components of the Environmental Impact Assessment (EIA) process, aimed at reducing or eliminating the adverse environmental and socio-economic impacts of mining activities [91]. These measures are designed to address specific issues identified during the impact analysis and ensure sustainable mining practices [92].

Proposed Mitigation Strategies

1. **Air Pollution: Use of Dust Suppression Systems and Emission Controls:** Mining activities generate significant dust and gaseous emissions, which can

adversely affect air quality [93]. To mitigate these effects:

- **Dust Suppression Systems:** Spraying water or chemical stabilizers on haul roads, stockpiles, and excavation sites reduces airborne particulate matter. For example, wet drilling techniques can minimize dust generation during mining operations [94].
- **Emission Controls:** Installing advanced filters and scrubbers in mining machinery and processing plants helps capture harmful gases like sulfur dioxide (SO_2) and nitrogen oxides (NO_x) [95]. Transitioning to cleaner fuel sources or adopting electric-powered equipment can further reduce emissions [96].

2. **Water Pollution: Wastewater Treatment and Controlled Discharge Systems:** Water contamination from mining is often caused by acid mine drainage (AMD) and chemical spills [97]. To address this:

- **Wastewater Treatment**: Implementing advanced treatment technologies, such as constructed wetlands or chemical neutralization systems, can remove heavy metals and other pollutants from mining effluents[98].
- **Controlled Discharge Systems**: Developing containment structures, such as tailings dams, prevents untreated wastewater from entering natural water bodies. Regular monitoring and maintenance ensure these systems remain effective [99].

3. **Soil Degradation: Land Reclamation and Rehabilitation Techniques:** Mining operations often strip the land of its topsoil, leaving it barren and prone to erosion [100]. Mitigation strategies include:

- **Land Reclamation**: Filling abandoned mining pits with soil or other materials restores the topography, making the land usable for agriculture or other purposes [101].
- **Rehabilitation**: Replanting native vegetation stabilizes the soil, prevents erosion, and promotes ecosystem recovery. Techniques such as hydroseeding can accelerate vegetation growth in degraded areas [102].

4. **Biodiversity Loss: Reforestation and Conservation Programs:** Mining activities, particularly in ecologically sensitive areas, disrupt habitats and threaten local wildlife [103]. Effective mitigation measures include:

- **Reforestation**: Planting trees and restoring forested areas can compensate for deforestation caused by mining. Using native species ensures compatibility with the local ecosystem [104].
- **Conservation Programs**: Establishing wildlife corridors and protected zones minimizes habitat fragmentation and supports biodiversity conservation. Collaborative efforts with NGOs and local communities enhance the success of these initiatives [105].

Implementation Plan

An effective implementation plan ensures that proposed mitigation strategies are executed efficiently and achieve the desired outcomes. Key components include:

- **Timeline**: A phased approach is adopted, starting with immediate measures (e.g., dust suppression) during the mining phase and long-term actions (e.g., reforestation) post-mining. For instance, replanting activities may be scheduled to coincide with the end of each operational phase [106].
- **Responsible Parties**: Clear responsibilities are assigned to stakeholders, including mining companies, regulatory agencies, and local communities [107]. Mining operators are tasked with implementing technical solutions, while government bodies monitor compliance [108]. Community involvement ensures local acceptance and enhances the effectiveness of conservation programs [109].
- **Resources Required**: Adequate funding, technical expertise, and human resources are allocated to ensure successful implementation. Collaboration with international organizations or adopting global best practices can provide additional support [110].

Public Involvement

Public involvement is a fundamental aspect of the Environmental Impact Assessment (EIA) process, emphasizing transparency, inclusivity, and collaboration. By actively engaging the community and other stakeholders, public involvement ensures that the social and environmental concerns of those affected by mining projects are identified and addressed [111]. This fosters trust, minimizes conflicts, and enhances the sustainability of the proposed activities.

Community Engagement

To effectively engage communities, a variety of participatory methods are employed:

- **Public Hearings**: Formal meetings are organized to provide project details and collect feedback from affected individuals and groups. Public hearings ensure transparency and give stakeholders a platform to voice their concerns [112].
- **Focus Group Discussions**: These small, interactive sessions with specific stakeholder groups (e.g., farmers, women, or youth) allow for in-depth exploration of localized issues, such as land use changes or water scarcity [113].

- **Surveys and Questionnaires**: Structured surveys help gather data on public perceptions, expectations, and concerns related to mining activities. This method is particularly useful for capturing the opinions of a large, diverse population [114]. For example, during the Thar Coal Project in Sindh, community engagement included a series of public hearings and surveys, enabling local voices to influence project planning [115].

Concerns Raised by the Public

Public consultations often reveal critical issues that may not be fully captured during technical assessments. Common concerns include**:**

- **Health Issues**: Communities near mining sites often report respiratory problems and other health issues caused by air pollution and water contamination [116].
- **Displacement**: Large-scale mining projects frequently involve land acquisition, leading to the displacement of local populations. This disrupts social structures and traditional ways of life [117].
- **Loss of Livelihoods**: Mining activities can negatively impact agriculture, fishing, and other livelihood sources, leaving affected communities economically vulnerable [118]. For instance, marble mining in Balochistan has resulted in reduced agricultural productivity due to soil degradation and water scarcity [119].

Incorporation of Feedback

How Public Concerns Were Addressed in the Mitigation Plan

Addressing public concerns is vital for gaining social acceptance and ensuring project sustainability. The approaches include:

- **Health Mitigation**: Installing air quality monitors and implementing dust control measures, such as wet drilling and vehicle emission controls, directly address community health concerns [120]. Regular health camps can also be organized to monitor and treat mining-related health issues [121].
- **Compensation and Resettlement Plans**: Displaced communities are provided with fair compensation, alternative housing, and access to basic services like education and healthcare [122]. For example, in the Thar Coal Project, a resettlement plan was developed to provide housing and jobs for displaced families [123].
- **Livelihood Restoration**: Training programs and alternative income-generating activities, such as eco-tourism or small-scale enterprises, are introduced to support communities impacted by mining activities [124]. Rehabilitated mining sites can also be converted into arable land or community spaces [125].

By integrating public feedback into mitigation strategies, the EIA process ensures that the concerns of affected populations are addressed, fostering trust and cooperation between mining companies and local communities [126].

Monitoring and Evaluation

Monitoring and evaluation (M&E) are critical components of the Environmental Impact Assessment (EIA) process, designed to ensure that proposed mitigation measures are implemented effectively and that the environmental impacts of mining activities remain within acceptable limits [127]. This process helps in adaptive management, allowing for course corrections based on real-time data and periodic assessments [128].

Monitoring Plan

Key Performance Indicators (KPIs) to Track Environmental Performance

To ensure effective monitoring, specific, measurable, achievable, relevant, and time-bound (SMART) indicators are identified to assess the environmental performance of mining activities [129]. Examples of KPIs include:

- **Air Quality**: Concentrations of particulate matter (PM2.5, PM10), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) in the surrounding atmosphere [130].
- **Water Quality**: Levels of heavy metals, pH, and chemical oxygen demand (COD) in nearby water bodies [131].
- **Soil Quality**: Parameters like nutrient levels, heavy metal content, and erosion rates in the impacted areas [132].
- **Biodiversity**: Species richness and population trends of key flora and fauna in the vicinity of the mining site [133].
- **Noise Levels**: Decibel levels around the mining site, particularly in residential and ecologically sensitive zones [134].

These indicators provide quantitative benchmarks to evaluate the environmental impact of mining and the effectiveness of mitigation measures.

Frequency of Monitoring and Reporting

Monitoring activities are conducted at regular intervals to capture variations in environmental parameters over time [135]:

- **Continuous Monitoring**: Automated systems are used for real-time tracking of critical parameters such as air and water quality. For example, continuous air quality monitoring stations (CAQMS) can be installed at strategic locations near the mining site [136].

- **Periodic Monitoring**: Quarterly or biannual assessments are conducted for parameters like soil quality and biodiversity [137].
- **Reporting**: Detailed reports are generated and submitted to regulatory bodies, such as the Pakistan Environmental Protection Agency (Pak-EPA), at predetermined intervals (e.g., annually) [138]. These reports include data analysis, trends, and recommendations for corrective actions if deviations are observed [139].

Periodic Review of Mitigation Measures and Their Effectiveness

Evaluation involves a systematic review of the mitigation measures implemented during the mining project to determine their effectiveness in achieving environmental and socio-economic objectives [140]. The steps in the evaluation process include:

- **Data Analysis**: Monitoring data is analyzed to assess trends and compare actual impacts with the predictions made in the EIA. For example, reductions in PM10 concentrations would indicate the success of dust control measures [141].
- **Stakeholder Feedback**: Input from local communities and other stakeholders is collected to identify unresolved issues or unintended consequences of mining activities [142].
- **Revising Mitigation Strategies**: If existing measures are found inadequate, alternative or enhanced mitigation strategies are proposed. For instance, if water treatment systems fail to meet quality standards, advanced filtration technologies may be introduced [143].
- **Compliance Checks**: Periodic evaluations ensure that the project adheres to national and international environmental standards, such as those outlined by the Pakistan Environmental Protection Act (1997) or the International Council on Mining and Metals (ICMM) guidelines [144].

Regular evaluation enhances accountability and fosters adaptive management, ensuring that the environmental impacts of mining are effectively controlled throughout the project lifecycle [145].

Recommendations

To address these environmental and socio-economic challenges, several key recommendations are proposed. First, there is a need to promote **sustainable mining practices** by encouraging the adoption of cleaner technologies, water recycling, and waste reduction strategies. Implementing best practices in dust suppression, water treatment, and land reclamation can significantly reduce environmental degradation [146]. Furthermore, **policy reforms** should be pursued, including strengthening the enforcement of environmental regulations and ensuring that mining companies adhere to EIA guidelines [147]. The government should also introduce incentives for companies that adopt environmentally friendly technologies, encouraging a shift toward sustainability [148]. **Capacity building** is essential, involving the training of local communities and mining operators in sustainable practices, environmental monitoring, and emergency response techniques [149]. Collaboration between the government, industry, and civil society is crucial for building a shared understanding of environmental responsibility [150]. In addition, strengthening **monitoring and enforcement** mechanisms is vital, especially in remote mining areas, to ensure compliance with environmental standards [151]. This includes the installation of real-time monitoring systems for air and water quality to track environmental impacts more accurately and respond quickly to potential issues [152].

Future Directions

Looking ahead, it is essential for Pakistan to integrate **modern technologies** and stricter regulations to ensure that mining activities remain sustainable. Emerging technologies such as remote sensing, drones for environmental monitoring, and automated machinery have the potential to significantly reduce the environmental footprint of mining operations [153]. Advances in water treatment, waste recycling, and carbon capture technology can help mitigate some of the negative environmental impacts associated with mining [154]. Moreover, **stricter regulations** should be put in place to enforce compliance, with stronger penalties for non-compliance to ensure that mining companies take their environmental responsibilities seriously [155]. Governments and regulatory bodies must create and enforce policies that hold mining companies accountable for the long-term health of the environment [156]. Finally, **integrated land-use planning** should be a key consideration for future mining projects, where the economic benefits of mining are weighed alongside the potential for ecological restoration, biodiversity conservation, and sustainable development [157]. Mining projects should be integrated into broader regional land-use plans to ensure that they contribute to long-term sustainability and do not compromise the health of ecosystems and communities [158].Incorporating these recommendations will help to create a more balanced approach to mining in Pakistan one that minimizes environmental degradation while contributing to the country's economic development in a socially and environmentally responsible manner [159].

Conclusion

The conclusion of the Environmental Impact Assessment (EIA) report synthesizes the findings from the entire process, highlighting major concerns and providing actionable recommendations to mitigate the negative environmental impacts of mining activities in Pakistan. Additionally, it outlines future directions for ensuring that mining operations are conducted sustainably and in alignment with both national and international environmental standards.

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