Natural and socio-economic impacts of stone quarrying: A study on tribal forest fringe village, Jamtoria Forest Beat (JFB), Purulia District, West Bengal, India.

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ABSTRACT

Stone quarrying activities extensively impact natural and socio-economic conditions. This review was conducted to evaluate the environmental perspectives of various stone quarrying units operating in the Jamtoria Forest Beat (JFB) in the Purulia district of India. The review employed both qualitative and quantitative methodologies with a sample size of 131 households and five key informants. The study relied on fieldwork, general observations, surveys, and laboratory experiments. The sampling methods included enumeration for quarry workers, stratified sampling for households, and purposive sampling for key informants. The chi-square cross-classification was used to test predictions at a 0.05 significance level, and the Ecosystem Service Index (ESI) was calculated to assess the spatio-temporal dynamics of ecosystem services. The results reveal serious outcomes in terms of massive dust and noise pollution, a decline in forest and land cover, loss of ecosystem services, loss of Non-Timber Forest Products (NTFP), land degradation, employment generation, accidents, financial struggles, and severe health hazards for people living near these units. Local authorities do not take adequate measures to minimize the adverse effects on the environment and human well-being. This survey reflects that administrative measures are crucial to protecting the environment and human well-being from various contaminations caused by these quarrying activities.

Keywords: Stone Quarrying, Tribal Behaviour, JFB, Environmental Impacts, Socio-Economic Impacts.

INTRODUCTION

Stone quarrying is a pervasive action that includes the extraction of stones from the world's outside layer for different development and modern purposes. While it contributes fundamentally to financial improvement by giving unrefined substances to framework projects, it additionally accompanies natural and social results that need cautious thought. This discussion will focus on the natural and socio-economic impacts of stone quarrying in Jamtoria Forest Beat (JFB), Purulia district, India. Natural impacts include habitat destruction, soil erosion, air pollution, water pollution, and noise pollution. Habitat destruction occurs when the excavation process alters the landscape, affecting local vegetation and biodiversity (Omosanya et al,2011). Soil erosion can cause sedimentation in nearby water bodies, disrupting aquatic ecosystems. Air pollution is caused by dust and particulate matter, which can negatively affect respiratory health for humans and animals. The fine particles can antagonistically affect respiratory wellbeing for the two people and creatures nearby. In Jamtoria Forest Beat (JFB), where air quality may currently be a worry, stone quarrying can worsen the issue. Water pollution occurs when contaminants seep into groundwater or run off into surface water bodies, affecting human and ecological health. Noise pollution is caused by heavy machinery, blasting, and transportation activities, disrupting the natural

acoustic environment and affecting wildlife and local communities (Awoke, et al., 2019). Socio-economic impacts include community displacement, health risks, and impact on livelihoods, such as agriculture. Quarrying can reduce the productivity of agricultural land, leading to financial difficulties and increased vulnerability for the local population. This can upset the regular acoustic environment, influencing untamed life and the prosperity of neighbourhood networks in Jamtoria Forest Beat (JFB), Purulia District. The review discusses the social and environmental impacts of stone quarrying in Jamtoria Forest Beat (JFB), Purulia, focusing on the uprooting of community networks, health risks, and the impact on livelihoods (Tripathi, 2016). It highlights the need for adequate resettlement and remuneration measures to mitigate these effects. Addressing these impacts requires careful planning, effective regulation, and measures to mitigate adverse effects, ensuring sustainable development that benefits both the economy and local communities.

Review of literature

Javed, M., & Mahroof, K. (2020) observed that quarrying operations, such as drilling, blasting, and crushing rock materials, significantly impact various aspects of the environment. Forests, as vital natural resources in India, are closely linked to tribal culture and economy, providing essential resources for primitive agriculture and the collection of forest products, thereby fostering a way of life for tribal communities.

Omosanya et.al (2011) likewise contended that quarrying negatively impacts the environment through vegetation destruction, animal disturbance, soil erosion, waterway siltation, vibration, and dust pollution. It can also harm natural, archaeological, and cultural sites as well as the nearby tourism industry.

Langer (2001) mentioned that dust, a visible and invasive issue in quarrying, can originate from various sources. It can be controlled through vegetation methods like mulching, sprinkling, and wind barriers, thereby reducing potential health and environmental concerns.

Lameed & Ayodele (2010) noted that quarrying significantly impacts water quality and routing by often removing vegetation and soil, which affects aquifer recharge quality and de-waters adjacent watercourses and wells. Quarrying also generates considerable employment opportunities, as it is a relatively labour-intensive and under-mechanized industry.

Stephens and Ahern (2001) indicated that mining remains a highly hazardous occupation globally, causing immediate injuries, fatalities, and long-term health issues like cancer and respiratory conditions. Prolonged exposure in mines can lead to hypertension, heat exhaustion, myocardial necrosis, and sensory system problems.

Awoke (2019) point out that quarrying causes environmental disturbance through engineering activities during extraction and processing, altering geomorphology and land use. It also impacts agricultural economies, providing employment, financial, and community benefits. For temporary workers, mining and quarrying serve as a significant source of employment during periods when farming or livestock yield little return.

Dutta (2004) noted that quarrying, a crucial human activity for infrastructure development, significantly impacts our environment, causing loss of living space, dust, vibrations, and chemical spills. It

also leads to breathing problems and abandonment of mined sites. Stone quarrying negatively affects the environment, society, cultural heritage, and workers' health, resulting in issues like child labour, gender disparities, and pollution.

Objectives of the study

Stone quarrying, a prevalent activity in many regions, plays a significant role in the construction industry by providing essential raw materials. However, its environmental and socio-economic impacts are subjects of concern. This study aims to delve into these aspects, focusing on a specific geographical area to offer a detailed analysis and understanding. So, paper objectives may be summarized as follows.

(a)To assess the impact of stone quarrying on natural environment of the study area.

(b)To analyse the socio-economic impacts of stone quarrying in the study area.

Study area

Dhurudih quarry site is a village in Manbazar-II Block in the Purulia district of West Bengal, India. It is part of the Burdwan Division. The village is located 62 km south of the district headquarters in Purulia, 4 km from Manbazar-II, and 209 km from the state capital, Kolkata. Jamtoria Beat includes the Boro range. The village, specifically Dhurudih (Latitude: 22°54'56.49"N, Longitude: 86°40'2.43"E), was deliberately selected for study due to its high concentration of indigenous communities and proximity to forest land. Two groups within 1.5 km of the nearest forest edge were identified, and a village-level survey was conducted with village representatives.

METHODOLOGY

Sample

Household surveys were conducted in the last week of March 2023 across approximately one forest-fringe village, Dharidih, encompassing 131 households. The sampling methods included enumeration for quarry workers, stratified sampling for households, and purposive sampling for key informants. Village Panchayat Officers, Beat Officers, and village elders were selected using purposive sampling. The study utilized a descriptive research design to assess the impacts of stone quarrying on the forest and human ecosystem in the Jamtoria Forest Beat (JFB) areas of the Purulia district, combining both qualitative and quantitative research approaches.

Materials of the study

This study used a combination of overview research and observational exploration to investigate the environmental and socio-economic impacts of unregulated stone quarrying in the Jamtoria Forest Beat area of Purulia District. Quantitative methodologies, including inferential, experimental, and survey approaches, were used to collect data from the field. The perception method was used to address concerns about natural effects through direct observation and interaction with the environment. Secondary data sources included government policy documents, notices, reports, regulations, acts, previous review reports, datasets, evaluations, and reports from international organizations and donor agencies (Awoke, et al., 2019). Data collection and processing were ensured through cross-checking, and the literature review provided a robust

foundation for analysing the field data. This comprehensive approach provided professionals with detailed insights into quarrying and stone crushing activities, ensuring a thorough understanding of the subject matter.

Procedure

To evaluate the spatio-temporal dynamisms of ecosystem services in two different areas, the Ecosystem Service Index (ESI) was employed separately for each area (Everard et al., 2019). The procedure involved several steps, detailed as follows: Each ecosystem service was transformed into a numeric score based on a scale ranging from 'significantly positive' (++) to 'neutral' (0), 'significantly negative' (–), and 'unknown' (?). These scores were based on the surveyors' understanding of stakeholders' responses. The ESI value was calculated using the following formula: $\boldsymbol{ESI} = \sum (\boldsymbol{n}+\mathbf{1.0} + \boldsymbol{n}+\mathbf{0.5}) + (\boldsymbol{n}-\mathbf{1.0} + \boldsymbol{n}-\mathbf{0.5})/ \sum \boldsymbol{ntota}$. Here, n+1.0 and n+0.5 represent the counts of significantly positive and slightly positive scores, respectively, while n−1.0 and n−0.5 represent the counts of significantly negative and slightly negative scores. N total is the total number of observations.

The Chi-square statistic ($\chi 2$) was calculated using the formula: $X^2 = \sum (O-E)^2 /E$ Where: O is the observed, E is the expected. This statistic helped in determining the significance of the differences between observed and expected frequencies. The study ensured the validity and reliability of data through cross-checking and data editing procedures to correct any errors. The collected data were processed and analysed using SPSS and Microsoft Excel, enabling the computation of the ESI, Chi-square statistics, and other relevant analyses.

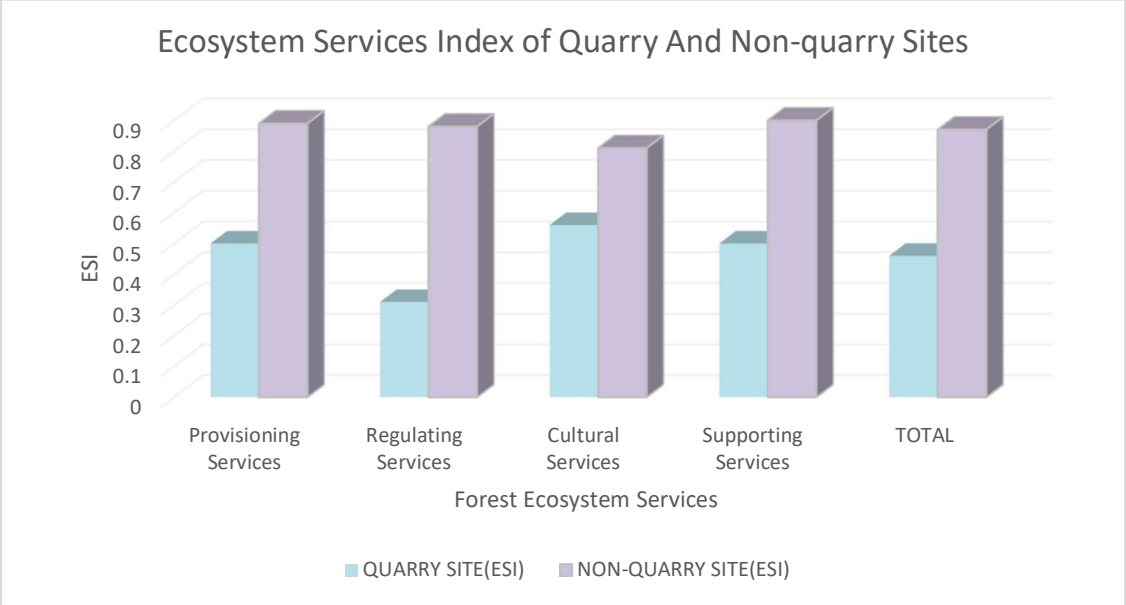
RESULTS AND DISCUSSION

The Social Impact Assessment (SIA) survey investigated the effects of stone quarrying on the local environment using interview techniques. Quarrying and stone squashing negatively impact the environment through contamination, deforestation, and land degradation. This affects agribusiness, human health, vegetation, and ranch ripeness. Environmental issues include air, noise, and land pollution. People living near quarry sites share their perspectives on the natural impact (Edwards, et al., 1991). A quarry is a place where rocks, sand, or minerals are separated from the earth's outer layer. It is often used interchangeably with 'mine', but the terms are distinct. Quarrying involves exhuming stones from sources for development, while mines involve separating minerals for metals. Quarrying involves uncovering hard or delicate rocks/stones from large, deep stores. The 'quarrying' process has eight steps or steps. These are: steps 1: make an arrangement to plan; steps 2: eliminate the top layer of material; steps Step 3: drill openings; steps 4: transport materials for handling; steps 5: a. process materials utilizing pulverizing; and b. increase the value of handled material; steps 6: transport completed items; steps 7: items used to make maintainable arrangements; and steps 8: items reused or re-utilized. Over the years, residents in the area have experienced air, dust, water, and noise pollution due to the misuse of cursing machines. The process involves slicing separated stones into chips for development, which are not suitable for composite materials due to their size. Quarrying activities near residential areas cause environmental issues such as vibration, dust, and noise

pollution. Residents complain about poor roads and heavy machinery usage, highlighting the need for better environmental management (Mahapatra, 2023).

Impact of stone quarrying on the environmental system: The Jamtoria Forest Beat (JFB), region, once known for its biological diversity, has been under threat due to unregulated stone quarries for the past seven years. These quarries level slopes, clear backwoods for mining, and set up stone crushing plans. The environment is now defenceless against automated quarrying, with 90% of all removed stones coming from cursing machines. The public authority licenses manual extraction, but the majority of stones are extracted through modern methods. Investigation reveals numerous openings and rises in forest, hillocks, and arable grounds, despite public authority orders for sand cover, causing destruction in Jamtoria Forest Beat (JFB) stone quarries (Javed, et al., 2020). The Ecosystem Service Index (ESI) values (Figure 1) for quarry (Provisioning Services score 0.5, Regulating Services score 0.31, Cultural Services score 0.56, and Supporting Services score 0.5.) and non-quarry sites (Provisioning Services score 0.89, Regulating Services score 0.88, Cultural Services score 0.81, and Supporting Services score 0.9.) were analysed. The non-quarry site provided higher provisioning services, such as food, water, and raw materials, indicating better environmental sustainability. The quarry site had a lower ESI, indicating reduced capacity to regulate ecological processes. The non-quarry site provided higher cultural services, such as recreational and aesthetic benefits, due to its natural state. The non-quarry site also provided higher supporting services, such as soil formation and biodiversity. The total ESI for the non-quarry site was 0.87, indicating a healthier, more sustainable ecosystem.

Figure 1 Ecosystem Services Index of Quarry and Non-Quarry sites of The Study Area



Impact on forest cover and Non-Timber Forest Product (NTFP): The total forest cover area before and after stone quarrying in the study area is measured in acres. The data reveals that there were 60 acres of

forest land before stone quarrying, which decreased remarkably to 35 acres after quarrying, indicating a 41.67% decrease in forest areas. This analysis suggests a significant negative impact on the forest ecosystem due to stone quarrying, with a notable reduction in forest cover. The area's social, economic, and ecological impacts are being exacerbated by excessive quarrying. There are 32 quarries in the area, impacting three ancestral villages and causing immediate harm to three individuals. Collaborative efforts between policymakers, industry stakeholders, and environmental organizations are needed to ensure responsible resource use. The data suggests complex dynamics in the socioeconomic impact of stone quarrying on Non-Timber Forest Product (NTFP) income, with both positive and negative consequences depending on the income range. A small 9.17% of respondents had a monthly NTFP income below 5,000 before stone quarrying, while 23.33% significantly increased their income to this level after stone quarrying, indicating a shift toward higher income levels in this category. A moderate 20% of respondents fell into this income range before stone quarrying, and 45.83% substantially increased their income to this level after quarrying, suggesting a significant positive impact on income. Conversely, a high 40% of respondents had a monthly NTFP income in the range of 10,000 to 15,000 before stone quarrying, with 15% experiencing a significant decrease in income after quarrying, indicating a negative impact on this income range. A substantial 30.83% of respondents had a monthly NTFP income above 15,000 before stone quarrying, with 15.83% experiencing a decrease, though not as significant, after quarrying, suggesting a moderate impact on income in this higher income range.

Impact of dust from stone crushing and quarrying on local flora: Dust generated from the destruction of trees and vegetation poses a major concern. Stone crushing and quarrying operations produce large amounts of dust, directly impacting local flora (Lameed,2010). The study found that *Aegle marmelos* (1.33 mg/cm²), a species with the highest dust load, is highly susceptible to dust accumulation due to its leaf surface characteristics or proximity to the source. Other species, such as *Moringa oleifera* (0.98 mg/cm²), *Azadirachta indica* (0.83 mg/cm²), *Ziziphus mauritiana* (0.78 mg/cm²), and *Madhuca longifolia* (1.05 mg/cm²), also showed moderate levels of dust accumulation. Additionally, *Neolamarckia cadamba* (1.12 mg/cm²) and *Butea monosperma* (1.09 mg/cm²) exhibited high dust loads, indicating their susceptibility to dust accumulation from stone crushing activities. Factors such as leaf morphology, surface characteristics, and growth habits can influence dust accumulation (Javed,2020).

Impact on Land Conversion and Degradation: Land conversion and degradation are significant effects of mining and quarrying activities, causing changes in landscapes due to unearthing, topsoil stacking, and waste unloading (Enger et al., 2002). Over the past six years, 47.25% of horticultural land has been converted to quarry areas, significantly affecting the environment. A Social Effect Evaluation review revealed this impact. Grazing land has the highest percentage of land use at 38%. Agricultural land recorded the lowest percentage at 14%, whereas forest land acquired a good concentration at 32%. In contrast, fallow land recorded only 16% of the total land in that area. Grazing land dominance indicates that a significant portion of the land before quarrying was utilized for animal grazing. The distribution of fallow land and agricultural land is relatively balanced, with fallow land accounting for 16.22% and agricultural land for

13.88%. Forest land constitutes a smaller percentage of land used for grazing, with a larger portion allocated to agricultural land. The ecological impact of quarrying includes the loss of farming area, land corruption, and water resource exhaustion (Omosanya et al., 2011). During the review period, quarry regions experienced significant growth and became the predominant land use, with quarry land use capabilities increasing by 21.53% annually. In contrast, horticultural and backwoods land use capabilities decreased by 26.43% and 9.20%, respectively. Unlawful stone-crushing plants significantly impact the environment, producing around 60,000 cubic feet of stone dust every month. This dust degrades air, soil, water, and stream systems, affecting arable land and hindering tree growth (Maponga et al., 1998). The plants lack a control system for dust production, causing trees to lose their fertility and fail to produce new fruit or vegetables. Land grabbing in the Jamtoria Forest Beat (JFB) region is a significant issue, with diggers and stone brokers exploiting government lands, rural areas, and tribal communities for stone quarrying and crushing. This has led to the displacement of ancestral communities and social struggles, primarily involving road hardships.

Impacts of stone quarrying on the socio-economic framework: Stone quarrying exerts significant impacts not only on the environment but also on the socio-economic framework of affected regions. As quarries operate, they alter the landscape and introduce various socio-economic dynamics that can profoundly affect local communities. These impacts encompass changes in employment patterns, income distribution, human health, human property, and cultural practices. Understanding these effects is crucial for assessing the overall sustainability and socio-economic well-being of regions where stone quarrying occurs. (Mahapatra ,2023). The accompanying conversation portrays the impacts of stone quarrying on the social arrangement of the Jamtoria Forest Beat (JFB):

Impact of dust contamination from quarrying on agriculture land: Dust contamination resulting from quarrying significantly impacts agricultural land, with the proximity to quarry sites directly influencing the severity of these effects. Air pollution from motor-driven drills, blasting, crushing, and material transportation serves as the primary source of contamination. Data reveals varying thicknesses of dust accumulation on agricultural land surrounding quarry sites, ranging from 1.56 cm to 2.78 cm, with Dhurudihi exhibiting the thickest accumulation at 2.78 cm. Dust accumulation around quarry sites can lead to reduced crop yield, soil degradation, health risks, environmental impacts, and aesthetic and economic concerns. It can reduce photosynthesis, alter soil properties, pose respiratory risks, affect biodiversity, and diminish marketability and economic value. Sixteen farmers reported a significant decrease in crop yield due to the deposition of dust and particulate matter. Furthermore, quarrying leads to the loss of fertile land that was once productive for farming.

Impact on human property and Aesthetic Value: Stone quarrying activities have resulted in soil contamination, which has led to problems with plant growth and loss of land, ultimately diminishing the aesthetic value of the site. According to the findings, the highest percentage of respondents (67.1%) stated that stone quarrying has a negative impact on physical health. Local elders who served as key informants reported that quarry workers are at high risk of physical injury due to materials used in operations striking

the body, and the presence of quarry dust that can harm the eyes. Supporting this observation, we witnessed in the field an incident where a quarry worker's hand was cut due to falling stones from higher levels to where he was positioned. The data indicates that 62.83% of respondents reported no property damage due to proximity to quarries and recent relocation, while 38.40% reported damage caused by dust accumulation during transportation and processing (Awoke, et al., 2019).

Impact of noise pollution from stone crushing activities on health: Noise pollution levels exceeding 65 decibels, set by the Division of Purulia, have been observed at stone crushing plants in Jamtoria Forest Beat (JFB), with minimum and maximum noise levels recorded at 90 dB and 120 dB, respectively. Activities such as hill blasting (118 dB), stone crushing (110 dB), and stone transport (90 dB) surpass both WHO (daytime limit of 70 dB) and Indian (daytime limit of 75 dB) standards, posing health risks such as hearing loss, stress, and cardiovascular problems. Long-term exposure to these high noise levels can lead to severe health consequences, despite being less intense than those from blasting and stone crushing activities. Additionally, the pollution adversely affects the health of local residents (Stephens, et al., 2001).

Impact on human health: Stone pulverizing causes serious air pollution issues in active mining and crushing sites. Workers are persistently exposed to high concentrations of dust, gaseous pollutants, elevated noise levels, and accidents, which pose a severe threat to the lives of workers and nearby communities. The information on various health effects obtained from the recent survey among the stone crushing labourers and the population living in and around mining sites is presented. The overall observations (Table 1) indicate that quarrying and crushing activities cause serious health issues, including respiratory problems (54.96%), eye conditions (12.97%), skin conditions (30.54%), and hearing issues (1.53%). After calculating the data, the overall observation showed that the quarrying and crushing activities cause serious health problems. Using the chi-square test, the probability of the alternative hypothesis is supported because the calculated chi-square value (86.23) is greater than the tabulated chi-square value ($\chi^2_{0.05} = 9.488$). We conclude that the null hypothesis is rejected, indicating a significant relationship between the variables. The respiratory problems observed in the present study included coughing, shortness of breath, chest pain, asthma, bronchitis, and others. Skin issues incorporate dryness and unpleasantness of skin (*Stephens*, et al., 2001). The workers are encountered with substantial exposure to dust and noise which may lead to manifestation of various occupational disease in long term. Activities such as digging, blasting, dumping, crushing, and loading release dust particles of varying sizes into the surrounding air. The workers are exposed to significant levels of dust and noise, which may lead to the development of various occupational diseases in the long term. The most common work-related infections among the stone crusher labourers and the surrounding communities are respiratory issues, hearing problems, eye ailments, skin conditions, fever, silicosis, blood pressure issues, and accidents (Awoke, et al., 2019).

Table 1 Health Problems of the study area

Sl.No	Health Problem	Hospitalized With Health Problem	Health Problem but Not Hospitalized	%
1	Respiratory Problem	72	0	54.96
2	Eye Problem	0	17	12.97
3	Skin Problem	0	40	30.54
4	Hearing Problem	0	2	1.53

Conflict arises between quarry company and surrounding villagers: The study reveals conflicts between a quarry company and nearby villagers due to boundary issues, tool loss, farm destruction, noise, dust, cracks, and mass wastage. Data reveals conflict between a quarry company and surrounding communities, with 67 respondents identifying causes such as dust, road block, noise, animal accidents, and blockage of animal pathways, accounting for 40.60%, 25.45%, 23.63%, and 3.03% respectively. Dust, air, noise pollution cause health issues, disrupt transportation, disrupt sleep, and contribute to habitat destruction and wildlife disruptions.

Quarrying as a Source of Employment and Job Strategies: Quarrying, a labour-intensive activity, provides significant employment opportunities in many countries, including Dhuridih, Purulia district, West Bengal. It benefits those involved by providing access to land, credit, tools, training, and information, thereby helping many individuals meet their business needs. The investigation revealed that 76.44% of the quarry labourer respondents, as well as 49.45% of the total sample population, considered the quarrying area as a primary employment strategy. Additionally, 17.81% of the respondents viewed it as a supplementary method to their occupation. Quarries have both negative and positive effects on nearby residents. 15.00% engage in business, 4.17% find employment, 12.5% obtain construction materials, and 68.33% do not see any benefit from the quarry. Participants in stone quarrying exercises cited neediness as a significant factor, Favouring it for protection and preferable pay over confidential area business and everyday tasks ((Bhattacharjee et al,2018)

Conclusion

This study examines the natural and socio-economic impacts of stone quarrying in Purulia, West Bengal, focusing on the effects on ancestral people in the Jamtoria Forest Beat (JFB) region. The area has experienced natural debasement, ecological dangers, and friendly changes. The unregulated quarrying has led to the obliteration of betel leaf development, forcing the tribal people to leave the region. The study suggests that quarrying should be economically managed, considering both natural and social aspects, to achieve a balance between financial growth and ecological and social prosperity. In these conditions, this study proposes the accompanying suggestions:

1. The government should focus on accelerating the nation's development and infrastructural improvement, allowing stone extraction to address challenges.

2. Manual quarrying should be used during rainstorms. The government should outline stone quarries to prevent damage to forests, slopes, hillocks, and arable terrains. They should boycott illegal stone-pounding plants and create reports against land snatching.

3. The government should also stop the removal of ancestral people from their properties by stone excavators. To address the effects of mining, restoration programs, agro ranger practices, and proper pit opening and reclamation are recommended.

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Conflict of interests

No competing interests.

Author's contributions

Both the authors contributed equally to the theoretical development, analysis, interpretation and writing of the manuscript.

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