Advanced International Journal for Research (AIJFR)
E-ISSN: 3048-7641 ● Website: www.aijfr.com ● Email: editor@aijfr.com

Assessing the Economic Significance and Environmental Consequences of Quarrying: An In-Depth Case Study of Hlimen Village

Dr. David A Lalramchulloa[1], Lalrintluanga Hrahsel[2], Ruthi Lalawmpuii[3]

[1]Assistant Professor, Department of Geography, Govt. J Thankima College, Aizawl
Email: daxsaiyan@gmail.com
[2]Assistant Professor, Department of Geography, Govt. J Thankima College, Aizawl
Email: stanley.lalrintluanga@gmail.com

Abstract

Quarrying is a longstanding human activity vital for procuring construction materials such as dimension stones and aggregates, yet it produces considerable environmental and social consequences. This study investigates the economic significance of quarrying and its environmental impact in Hlimen, Mizoram—a region notable for its compact and hard stones. Utilizing both primary and secondary data collected via surveys, interviews, and field observations of 100 households, the research highlights quarrying's contribution to local infrastructure, employment, and household incomes. However, the analysis reveals pervasive negative impacts: habitat loss, dust and noise pollution, land degradation, hydrological disruption, and increased health complications among workers and residents. Social consequences include upsurges in migration, crime, and conflict over land use between agriculture and mining. Positive economic outcomes are primarily seen in increased business opportunities, land value, and transport services. The study recommends implementing robust rehabilitation, landscape management, and protective regulations to mitigate adverse effects and promote sustainable livelihoods. Sustained quarrying offers tangible economic benefits but the health and ecological costs necessitate comprehensive intervention and collaborative stakeholder planning.

Keywords: Quarrying, Aggregates, Habitat loss, Land degradation, Hydrological disruption, Migration, Land use conflict, Mining

1. Introduction:

Over millions of years, the interplay of intense heat and pressure within the Earth's crust resulted in the formation of natural stone blocks such as granite, marble, travertine, limestone, and slate. Geological processes involving the uplift and erosion of the Earth's crust subsequently exposed these mineral deposits, commonly known as quarries (Dolley, 1999). Historically, quarries have served as crucial sources of building materials; for instance, the ancient Egyptians extracted massive limestone and granite blocks by hand from local quarries to construct the Great Pyramids, with individual blocks weighing several tons (Gunn & Bailey, 2003).

Quarrying refers to an open-pit mining method where dimension stones, rocks, construction aggregates, riprap, sand, gravel, or slate are excavated from the surface. This activity differs fundamentally from underground mining, which takes place at significant depths below the earth's surface. Stone quarrying predominantly occurs in hilly regions rich in stone reserves and typically utilizes drilling and blasting techniques to fragment the rock masses. It is not uncommon for several hundred explosive charges to be detonated simultaneously, producing up to 20,000 tons of fragmented stone in a single blast. The resultant broken material is then crushed and screened into various uniform sizes for commercial use (Lad & Samant, 2014).

The methods employed for stone extraction have evolved considerably since the earliest recorded quarries at Aswan, Egypt, where tools such as hammers, picks, and chisels made of stone or metals like bronze and iron were utilized. Contemporary quarrying techniques are broadly divided into two categories: non-blasting and blasting methods. The non-blasting method involves manually detaching rock blocks using hand tools or specialized channeling machines without the use of explosives. This approach is particularly suitable for soft and layered rock formations. Initially, the overlying soil cover is cleared to expose the rock surface, which is then systematically separated into blocks of desired sizes by methods such as wedge insertion or channel cutting. In contrast, blasting quarrying uses controlled explosive charges to break apart hard rock types such as granite, basalt, trap rock, quartzite, and sandstone. This method is often more economical and efficient for these durable materials. The process entails precise drilling of blast holes, calculated loading of explosives at specific depths, and controlled detonation, all requiring operators with expertise in rock mechanics and explosive handling (David & Patric, 1998).

Quarried stones serve varied purposes, with two primary categories being dimension stones and aggregates. Dimension stones—large, accurately cut blocks—are used for construction, monuments, and architectural decoration, whereas aggregates such as sand, gravel, and crushed rock provide foundational materials for roadways and railroads and serve as raw materials for concrete and asphalt production (Dolley, 1999). Although quarrying contributes positively to economic development, communities adjacent to the Hlimen quarry have raised concerns over environmental disturbances. These include noise pollution from blasting and heavy machinery, dust clouds contributing to respiratory ailments such as cough and elevated blood pressure, and the deterioration of roads from heavy transport vehicles. Consequently, this study seeks strategies to mitigate these environmental and social challenges to promote sustainable quarrying operations in the region.

1.1 Study area:

The study area is situated approximately 7 km south of Aizawl, the capital city of Mizoram, in the village of South Hlimen. It is geographically positioned between latitudes 23°43’38” N and longitudes 92°43’04” E, encompassing an area measuring 243.84 meters in length and 396.34 meters in breadth, totaling roughly 96,643.54 square meters. The village lies on the slope of a mountainous range originating from Melthum, characterized as a mountainous region with young and immature terrain featuring moderately steep slopes. The landscape is hilly with altitudes ranging from 1000 to 1100 meters, predominantly composed of tertiary Bhuban subgroup rocks. The highest elevation within the area reaches 1065 meters above sea level, with the bedrock overlaid by uneven soil layers mainly

consisting of thinly bedded shale. Hlimen is well-known across the state for its quarrying activities owing to the compactness and hardness of its stones. A road traverses through the center of the study area, connecting it to the neighboring Lungleng village.

The region frequently experiences severe landslides that cause significant loss of life and property. At the quarry site, rock formations exhibit an approximate north-south orientation with a 45° dip toward the west, intersected by east-west trending vertical joint planes. The bedding and joint surfaces lack asperities, resulting in relatively smooth discontinuities. Consequently, vegetation roots are shallow; thus, clearing vegetation leads to loosened soil susceptible to rapid erosion from direct rainfall. Additionally, overburden at the quarry is almost negligible. The area falls under the influence of monsoonal climate, receiving heavy rainfall predominantly from May through October, with an annual precipitation of about 250 cm. Around 90% of this rainfall occurs during the monsoon period, while the remaining 10% falls during the dry season from November to April, providing essential water resources for irrigation, drinking, and household consumption (Dr. Beingachhi & Deka, 2013) .

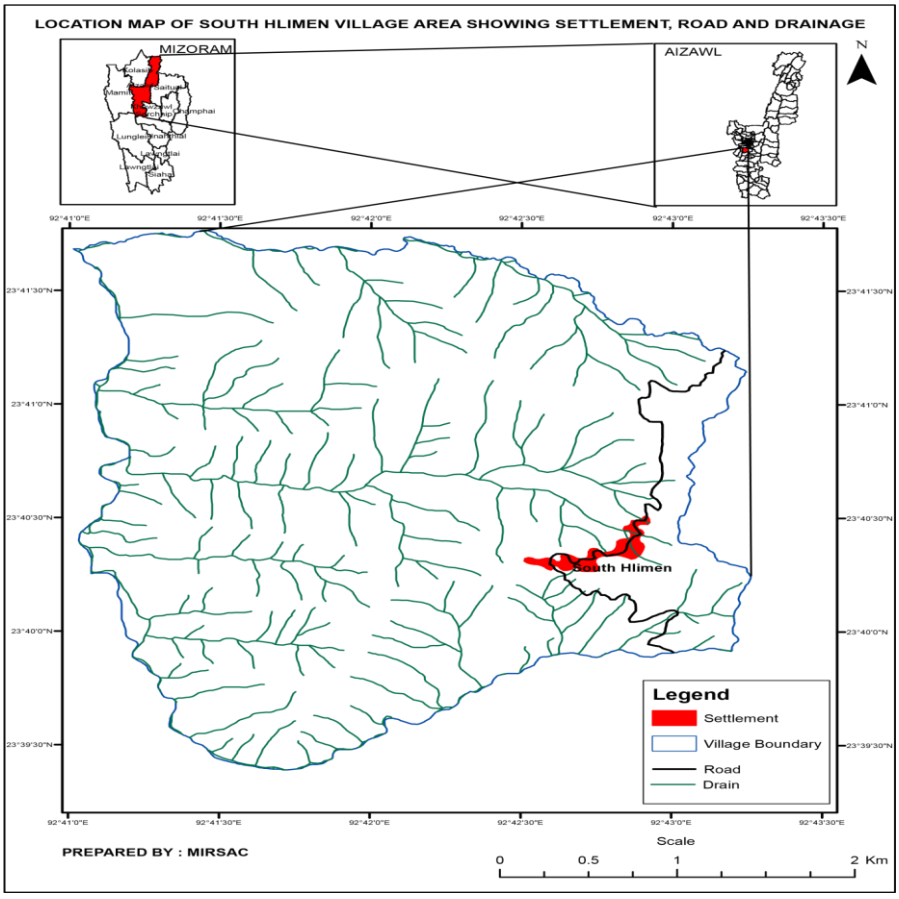

Fig 1.1: Location Map of South Hlimen Village Area

1.2 Statement of the problem:

1. Quarrying significantly alters the natural environment by displacing large volumes of soil and vegetation, resulting in habitat loss and forced displacement of local wildlife.

2. Abandoned quarries in Hlimen rarely retain enough topsoil to allow natural regeneration of vegetation and ecological restoration.
3. The area experiences frequent landslides exacerbated by the removal of vegetation, soil loosening, and heavy monsoon rainfall.
4. Dust and noise pollution generated from quarry blasting and crushing adversely affect the health of residents, causing respiratory diseases, skin infections, headaches, and psychological distress.
5. Quarrying traffic damages local road infrastructure, creating transportation challenges and contributing to environmental degradation.
6. Socioeconomic impacts include an influx of migrant labor leading to demographic changes, social conflicts, increased crime rates, and strain on community resources.
7. There is disagreement over land use, with tensions between traditional agricultural practices and expanding quarry operations.
8. Safety hazards from open quarry pits endanger workers and local populations, contributing to accidents and health risks.
9. Economic benefits from quarrying are disproportionately realized by quarry owners, while local communities bear the negative environmental and social consequences, leading to persistent local conflicts.
10. Rehabilitation of quarry sites is inadequate due to financial constraints and absence of stringent regulatory enforcement.

2. Methodology

This study is based on both primary and secondary sources. Primary source include field survey, general observations, questionnaire, interviews. Secondary source include books and journals. Field survey and general observations is made to assess the effects of dust pollution on environment. For assessing the effects of dust and noise pollution on workers and local residents residing near these units, questionnaires method and interviews has been used, the same goes for assessing the economic effects. A structured questionnaire to know the local people's perception about the impacts of quarrying is administered in the field during the study.

Questionnaires and interviews are done from 100 households which consists of several objective questions. The collected data has been analysed with the help of statistical techniques and maps wherever necessary. For selecting sample size of household, simple random sampling has been used. The household simple random sampling cover not less than 20%.

The main statistical technique employed in analyzing data is narrative analysis in which data is analyzed from various sources such as interviews of respondent and observation from the survey.

3. Results and Findings:

Hlimen stands as one of the largest and most prominent quarry sites in Mizoram, recognized for its stones that are sufficiently hard and dense, making them ideal for various construction applications. Prior to the commencement of quarrying activities, the area was richly covered with dense natural

vegetation, and certain sections were cultivated as gardens by local residents. This natural vegetation served as an important source of building materials for the community's residential needs and other uses. A road traverses the hillside through the area, alongside which several residential dwellings were established. The region has historically experienced frequent minor landslides. Initially, the site was not designated for quarrying, but the concept of converting the land into a quarry took shape around 1974, with stone extraction officially beginning in 1975. The quarry is under local ownership, and during its early phase, the quarried stones were primarily used to satisfy local construction demands rather than commercial purposes. Over time, the operations expanded, and the quarry began supplying the majority of building materials required for construction in Aizawl city (Dr. Beingachhi & Deka, 2013) .

Due to extensive stone excavation, the quarry's foundation became unstable, culminating in a catastrophic landslide on August 9, 1992. This disaster resulted in the loss of approximately 70 lives and significant destruction, including damage to 22 houses as well as eight stone crushers and air compressors. The estimated value of the property damage was about Rs. 100 lakh. Following safety concerns raised by local residents, the state administration ordered the quarry's closure for three years. Recently, operations have resumed on a smaller scale, including the collection of rock boulders from the failed slope (Dr. Beingachhi & Deka, 2013) .

3.1 Demographic characteristics:

The study area has a total population of 2,733, comprising 1,404 males and 1,329 females, and encompasses 564 households according to the 2011 census. The residents of Hlimen are engaged in diverse economic activities, including quarrying, government and non-government employment, subsistence business activities, and mixed labor. The majority of the population is involved in agriculture, followed by government jobs and quarrying-related work. Although the landowners are predominantly indigenous to Hlimen, most workers in the quarry and stone crushing sites are migrants from different states outside Mizoram. Approximately 70 percent of the workers are migrants, while 30 percent are natives, and the migrant workforce is largely illiterate. Many of these migrant workers identify as landless youths originating from rural areas, who have settled permanently in the region due to long-term employment opportunities in quarrying and associated activities. The influx of migrant labor has had both positive and negative effects on local social structures and the economy. According to responses from open-ended questionnaires, local residents indicated that the proximity of the quarry has created market opportunities for house renting, transportation services, and the sale of tools and food items, thereby facilitating a shift towards urban economic activities. Conversely, respondents also reported increases in alcoholism, prostitution, and other crimes, which have adversely affected the community (Dr. Beingachhi & Deka, 2013) .

Characteristics of respondence	Frequency	Percentage %
Age		
Less than 18	-	-
18-25	32	32
25-40	39	39
40-55	20	20
Above 55	9	9
Total	100	100
Gender		
Female	32	32
Male	68	68
Total	100	100
Education level		
Illiterate	33	33
Primary	36	36
Secondary	21	21
Tertiary	10	10
Total	100	100
Marital status		
Married	64	64
Single	36	36
Total	100	100
Number of dependents		
2	18	18
4	30	30
5	33	33
>5	19	19
Total	100	100

Table 3.1: Demographic data

Table 3.1 indicates that a larger proportion of males (68%) than females (32%) are involved in stone quarrying activities in Hlimen, suggesting that these occupations are predominantly male-dominated. The age group with the highest representation among respondents was 25–40 years (39%), indicating that many young people, possibly facing unemployment, primarily depend on stone quarrying for their livelihood. Conversely, the least represented age group was those over 55 years (9%), typically

considered elderly and less physically capable of performing strenuous quarry work. Married respondents constituted the majority (64%), while singles represented 36%, implying that married individuals may rely on quarrying to support their families. Additionally, most respondents had attained only primary education (36%), with the smallest proportion having tertiary level education (10%), suggesting that individuals with lower educational attainment are more likely to engage in quarrying due to limited alternative employment opportunities.

Regarding household dependents, the majority of respondents (33%) reported having more dependents, whereas those with fewer dependents (18%) formed the minority, indicating that individuals with larger family responsibilities may be compelled to undertake physically demanding quarry work to provide for their dependents (Dr. Beingachhi & Deka, 2013) .

3.2 Impacts on environment and community

Negative impacts:

It was observed that large scale dust is produced in and around the stone crushing and quarrying units functioning in the area from unloading of raw material to open stocking of crushed products of different sizes. During field survey it was observed that dust is directly affecting local flora/vegetation and agriculture as largescale dust is observed in the surrounding atmosphere, on vegetation, on agricultural crops and grasslands. Due to open stock pilings, whenever wind blows considerable amount of fine dust get suspended in the air adding to reduced visibility and the problems of air pollution. Even during non-operation of these crushing unit, substantial amount of dust emissions are also observed in the stone crushers cluster area.

During interaction with the residents regarding the effects of dust on health it is revealed that 90% of the residents have knowledge about dust as pollution, 30% of the respondents stated that it effects health, 50% stated that it causes skin infections like rough and dry skin, 70% stated that it causes respiratory diseases like asthma, inflammation, cold, cough, allergies, throat and chest infection etc.

Due to pervasive, irritating and loud noise, mostly the housewives, old aged persons, children and students suffers a lot and have developed certain physical, physiological and psychological disturbances. During interaction 30% of the respondents reported that noise produced by stone crushing and quarrying units results in mental tension, 40% respondents reported that it results in anxiety, 80% stated that it causes headache ,80% stated that it results in irritation, 20% reported that it results in high blood pressure,50% reported that it causes insomnia, 50% reported that it is resulting in stress and discomfort, 10% reported that causes emotional disturbances. 60% of the respondents reported that continue loud and annoying noise effects the studies.

According to National Academy of Sciences (2011) noise can cause deafness, psychological disorientation, stress, restlessness, irritability, triggers hypertension and lack of concentration and that one of the most frequent complaints the public makes to the crushed stone industry situated near population centres is about blasting noise. The primary source of noise from extraction of stones was from earth-moving equipment, processing equipment, and blasting. The truck traffic that often accompanies aggregate mining was a significant source of noise as well.

The most obvious engineering impact of quarrying was a change in geomorphology and conversion of land use, with the associated change in visual scene. This major impact was accompanied by loss of habitat, noise, dust, vibrations, chemical spills, erosion, sedimentation, and dereliction of the mined site. This concurs with Gunn and Bailey (2003) findings that quarrying activities are responsible for land degradation by way of earth moving where an entire hill can be blown away in a short time and the deformations may be impossible to restore to their original state or perform functions as before.

Flora and Fauna devastation (16%) was an over whelming impact caused by quarrying activities through vegetation destruction and land transformations which involved stripping of top soil to expose stones for extraction and this left the land bare and prone to erosion and other agents of nature. This is in agreement with the findings of Vermeulen & Whitten (2009) who explained that many rocky hills have one of the most peculiar terrestrial ecosystems with many species of bats, birds, other animals and plants roosting in the transition zones of such hills and adaptations confine these species to such habitat; they cannot survive elsewhere so stone quarrying may lead them into extinction.

Hydrological impacts (11%) were also identified where stone quarrying activities destroyed vegetation and underground water systems disturbed through deep excavations up to water table that created an imbalance in the underground hydrological systems as well as the sedimentation of streams and rivers from quarry deposits. This was in conformity with the findings of Vermeulen & Whitten (2009) who commented that quarrying may intersect active ground-water conduits or cause their blockage, ground water withdrawal and diversion of surface water may cause aboveground and underground hydrologic systems to dry up and such areas may be inhabited by some site-endemic species which may disappear with them, the species environment may lead to the extinction of the whole communities. Also, lowering the water table can increase the thickness of the unsaturated zone which can change the pH of the water and the biotic environment which can kill species that live there.

Notwithstanding, quarrying is a source of raw material (chipping and other stone aggregates) for building and road construction projects but the condition of the road is worse due to the frequent movement of heavy loaded trucks.

Positive impacts:

The wages and self-employment were the highest outcome of stone quarrying to individuals who worked in stone quarries and their households. Since stone quarrying engage most of the workers' time and yields economic benefits, it has been identified as a source of employment to many people. The forms of employment noticed were; self employment for those who had permanent working places, and wage employment for those who carried out some activities within the quarry for a pay.

Financial capital was also identified as another big outcome of stone quarrying work generated in form of personal savings and ploughing back to productive sectors of stone quarrying business. The stone workers were able to labour and earn monetary incomes from stone quarrying which were used in satisfying a wide range of their material needs. They were also able to acquire fixed assets such as; land, livestock, houses and retail business which provided them with additional income hence reducing their vulnerability to economic shocks.

Stone quarrying also provided avenues for acquisition of skills (15%) as stone workers laboured to extract and modify stones to the required specifications for sell under the guidance of the most experienced ones.

The formation of working groups forms part of the social network, stone quarrying involves several processes; the use of simple tools to perform some activities makes the work strenuous. For the women, for example, it takes them approximately two to three weeks to fill a five tonne truck singlehandedly. It is on this note that some workers decide to crush stones in groups and a lump sum of money would be given to each of the group members periodically. This not only help them take a shorter time but at least every member of the group gets a reasonable amount of money which she would invest in any area of her need.

Outcome	Frequency	Percentage
Increased businesses	20	20
Increase in transport services	18	18
Land values increased	16	16
Increased demand of agricultural products	9	9
Employment	25	25
Development of services	5	5
Infrastructural development	7	7
Total	100	100

Table 3.2: Positive outcomes of stone quarrying to the community

According to table 4.2 employment creation (25%) was the greatest outcome of stone quarrying to the community. The study found out that stone quarrying provided full time jobs to the communities living near quarry sites and beyond. The stone workers were able to labour and earn monetary incomes from stone quarrying activities which were used in satisfying a wide range of their material needs and acquisition of assets. Increase in income increased ones well-being in terms of health, wealth and general contentment.

Increased businesses (20%) was the second because of the immigrant workers to stone quarries, the population grew in and around the stone quarry sites, hence, the demand for many products and services increased which provided good environment for business to the local community.

The population working in quarrying did so on full time basis and therefore had no time to do farming, therefore, the farmers also benefited economically from the increased demand of agricultural products.

Land became more valuable because of quarrying activities as plots of land appreciated in value. With the increase in demand for housing facilities and companies constructing in the area the demand for land went up leading to an increase in the prices for plots of land. Increase in transport services was also noticed in the areas adjacent to the quarry areas; although it was listed as the least outcome of stone

quarrying, traffic characteristics changed from bicycles, motor cycles, cars and light goods vehicles to heavy trucks which affected the area in terms of damaging the roads, creating dust clouds from tyres rubbing gravel road surfaces and noise.

Plate 3.2.1 & 3.2.2: Wasteland generated by quarrying

Plate 3.2.3 (c): Dust stock piling up

3.3 Activities involved in Quarrying

At present, there are 16 quarries and 23 stone crushers operational at the study area, which are under the management of different landowners and workers. The oldest section was quarried in 1975. According to the survey and interviews held at the site of working, the activities carried out in quarries and stone crushing units are different.

The process starts by breaking off large chunks of rock from the quarry walls, usually through controlled blasting. This rock is then moved using loaders and trucks to a crusher. The crusher reduces the overall size of the material to make it easier to process. It is then put through a sorting or screening

process to ensure the resulting aggregate is of the correct size and shape and to remove impurities. The aggregate is then stockpiled and transported to concrete batch plants or local construction sites where it is required.

Quarrying material for use in building materials was much more work. Stones had to be carried or dragged out of quarries manually. Stones could also be hauled with pulley systems involving ropes and moveable wooden tracks or sleds. There are also several unskilled workers working at the site performing unskilled manual job.

Plate 3.3.1: Unskilled manual job in quarry

Plate 3.3.2: A crusher site

4. Suggestion and Conclusion

Suggestion

There is need for developing cost-effective rehabilitation methods and basic business management training of landowners. Furthermore, the increased quarrying activities should be matched with an effective landscape management to ensure lowering of the negative impacts of stone quarrying on the environment and the socioeconomic status of the people living around quarry zone.

The health hazards could also be mitigated through the use of protective equipment such as goggles and hand gloves at the quarry site.

The illegal way of extraction of stones should be restricted to preserve the geological resources of the area. There is need to ensure that mining operations are conducted in such a way that in broader scale it benefits the society and that concerted efforts are made to ensure that these benefits can be sustained even when mining activities become stopped.

Scientific planning and effective collaboration involving all the stakeholders would make the extracting activity socio-economically beneficial to the communities as well as environmentally sustainable. Proper and organized maintenance of small scale quarry operations will create better opportunities for diverse livelihood, income and assets that will promote positive livelihood outcomes.

Conclusion

This study aimed to assess the importance and impact of stone quarrying on economic and environment and the community of the study area. Quarrying activities were perceived to have positive and negative impacts on the environment and the socioeconomic wellbeing of the people and the community. The quarry firm and the landowners were the responsible parties for quarry rehabilitation. Lack of financial support and lack of a compulsive legal framework were perceived as main limitations to land rehabilitation.

In spite of the hazardous nature of the work, data collected from the field revealed that it sustains livelihood in terms of employment and family income. This consequently contributes to the well-being of workers and their families. However, it has been observed that stone quarry has negative implications on environment. Also many workers employed were from outside the area and from different states. In the study area, it has contributed to land degradation, erosion, destruction of forests, arable lands, loss of habitat for some animals and plant species as well as air pollution. This adversely affects the ecological balance of the area. Finally, it has also been observed from the field that stone quarrying is not devoid of health problems. Eye problems, bodily pains, chest problems, coughing, respiratory problems, and injuries are some health challenges that confront workers in the industry and the people living near the working sites. It is therefore concluded that though stone quarrying contributes significantly to livelihood survival, it has greater health implications on workers in the industry.

References

1. Barksdale, (1991). Mining laws and guidelines (Vol. 2). Sage Publishers Inc.
2. Bewiadzi, S., Awubomu, R., & Meni, N. G. (2018). Searching and cracking: Stone quarrying, livelihood, and the environment. Journal, 26(SI), 149–166.

3. Chauhan, S. S. (2010). Mining, development and environment: A case study of Bijolia mining area in Rajasthan, India. Journal of Human Ecology, 31(1), 65–72.
4. Corbin, J. (2008). Sustainable livelihood guidance sheets. Department for International Development (DFID).
5. David, L., & Patric, C. (1998). Quarrying as an anthropogenic geomorphological activity. Geomorphology, 31–39.
6. David, L. (2007). Anthropogenic geomorphological and after-use problems of quarrying. Journal, 30, 161–165.
7. DGSM. (2003). Sectoral environmental and social assessment for the mineral sector development technical assistance project.
8. Dolley, T. P. (1999). Crushed stone. Geological Survey Minerals Yearbook, 73(11), 1–73.
9. Dr. Beingachhi, B., & Deka, G. (2013). Landslide and associate environmental problems: A case study of Hlimen in Aizawl.
10. Durvasula, R. (2010). Occupational health information systems in developing countries - India: A case study presented at the IV Takemi Symposium.
11. Government of Mizoram. (2001). Census of India 2001 (Series 16; Mizoram). Director of Census Operations, Mizoram.
12. Gunn, J., & Bailey, D. (2003). Geomorphic impacts of stone quarrying.
13. ILO. (2009). Social and labour issues in small-scale mines.
14. Lad, R. J., & Samant, J. S. (2014). Environmental and social impacts of stone quarrying. International Journal of Environmental Science, 6(3), 5664–5669.
15. Manzoor, J., & Khan, M. (2020). Environmental perspective of stone crushing and quarrying. International Journal of Environmental Science, 15(1), 68–79.
16. Pachuau, R. (1994). Geography of Mizoram. R.T. Enterprise.
17. Uglow, D. (1999). Mitigating the environmental impact of artisanal quarrying: Consideration of awareness and incentives: A report for DFID/ITDG (ADD029). Department for International Development.
18. Wareru, S. W., Njoroge, J. B., & Adimo, A. O. (2018). Management status and perception of post quarried sites in Ndarugu Kiambu, Kenya. Journal, 12(8), 268–282.
19. WHO. (2009). Prevention and control exchange: Hazard prevention and control in the work environment.
20. William, H. L. (2001). Potential environmental impacts of stone quarrying in karst.