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Effect of mining activities on neighbouring environment and eco-restoration/ management plan for abandoned mining sites.

Efecto de las actividades mineras en el medio ambiente vecino y plan de gestión/restauración ecológica para sitios mineros abandonados

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ABSTRACT

Mineral resource mining and its exploitation have a significant influence on water, biological resources, as well as the socio-economic conditions of the surrounding area. Surface mining industries of Jhansi are facing environmental problems due to unscientific mineral resource mining. Quarrying activity produces massive dumps on the mining area. However, quarries damages not only the land surface but also the natural vegetation as well as biodiversity. In other words, the severity of mining activities are not only deteriorating the land surface but also restricting the living entities. The abounded mining area in north-eastern part of the District Jhansi were verified and validated by field survey conducted in the year 2021. The geographical location of the selected quarry sites ranges from 25° 26' 27.2616'' to 25° 28' 17.508'' N and 78° 39' 5.184'' to 78° 41' 49.3008'' E and the total geographical area is 1532.18 ha. The study was accomplished in four parts i.e., (i) existing state of neighbouring villagers in terms of land resources, (ii) environmental imbalance and eco-friendly changes of neighbouring villagers, (iii) management plan for suitable mitigation measures and (iv) development plan for restoration of abandoned mining sites through afforestation, vetiver grass plantation, development of nature trails, grazing land, aqua-cultural practices and rain water harvesting etc. The results concluded that the health of mining workers is directly affected by stone dust which makes them vulnerable to life-threatening respiratory disorders. About 50% participants facing multiple diseases and about 15% are facing single disease. The mining/quarry area may be developed as above mitigation measures. It is also suggested that remote sensing and GIS/ GPS technique integrated with drone technology may be very helpful for live/ post monitoring of developed mining areas.

Keywords: Eco-restoration, environmental imbalance, mining activities, mitigation measures.

RESUMEN

La extracción de recursos minerales y su explotación tienen una influencia significativa en el agua, los recursos biológicos, así como en las condiciones socioeconómicas del área circundante. Las industrias de minería a cielo abierto de Jhansi enfrentan problemas ambientales debido a la minería de recursos minerales no científica. La actividad de explotación de canteras produce vertederos masivos en la zona minera. Sin embargo,

las canteras dañan no solo la superficie terrestre sino también la vegetación natural y la biodiversidad. En otras palabras, la severidad de las actividades mineras no solo está deteriorando la superficie terrestre sino también restringiendo las entidades vivas. La abundante zona minera en la parte nororiental del distrito de Jhansi se verificó y validó mediante un estudio de campo realizado en el año 2021. La ubicación geográfica de las canteras seleccionadas varía de 25° 26' 27,2616'' a 25° 28' 17,508' ' N y 78° 39' 5.184'' a 78° 41' 49.3008'' E y el área geográfica total es de 1532.18 ha. El estudio se realizó en cuatro partes, es decir, (i) estado actual de los aldeanos vecinos en términos de recursos de la tierra, (ii) desequilibrio ambiental y cambios ecológicos de los aldeanos vecinos, (iii) plan de gestión para medidas de mitigación adecuadas y (iv) plan de desarrollo para la restauración de sitios mineros abandonados a través de forestación, plantación de pasto vetiver, desarrollo de senderos naturales, tierras de pastoreo, prácticas acuícolas y recolección de agua de lluvia, etc. Los resultados concluyeron que la salud de los trabajadores mineros se ve directamente afectada por el polvo de piedra que hace vulnerables a trastornos respiratorios potencialmente mortales. Aproximadamente el 50 % de los participantes enfrentan múltiples enfermedades y aproximadamente el 15 % enfrentan una sola enfermedad. El área de minería/cantera se puede desarrollar como las medidas de mitigación anteriores. También se sugiere que la técnica de detección remota y GIS/GPS integrada con tecnología de drones puede ser muy útil para el monitoreo en vivo/posterior de áreas mineras desarrolladas.
Palabras clave: Eco-restauración, desequilibrio ambiental, actividades mineras, medidas de mitigación.

INTRODUCTION

Land is one of the most valuable resource which provides food, fibre, medicine, minerals, and other necessities. Land resources are crucial in shaping man's economic, social and cultural advancement. One of the most valuable land resource is the rock. Rock is a mineral assemblage and play a critical role to any country for the development of industrial growth, social advancement and wealth. These are required for fundamental human requirements. Rocks, on the other hand, are finite and non-renewable in nature. Once a mineral was extracted from the soil, it was lost incessantly, not just for either present generations, but for all future generations (Reddy, 2008).

Mineral resource mining and exploitation have a significant influence on water, biological resources, air and land, as well as the socio-economic situation of the surrounding population. Its main focus on the environmental difficulties that surface mining industries of Jhansi are facing. The level and focus of mining activities influenced the amount of the impact on geological as well as geomorphological environment. It causes significant damage to the earth's landscape and ecological ecosystems (Ghose and Majee, 2001).

Quarrying and crushing procedures include excavating or blasting for rock formations. Mining activities typically have a negative influence on land resources and the topography of mining sites. Unscientific quarrying and crushing endangers the ecosystem, reducing natural resource and biodiversity. The environment of surrounding quarrying operations is being obliterated by the problems of abandoned materials dumps (Sarma and Kushwaha, 2005). Quarrying and open cast mining entail the excavation of massive pits on the ground surface to recover surficial and superficial deposits, as well as the blasting of surface rock and inorganic deposits to remove the material. The degree to which these processes are mechanised is largely determined by the value of the mineral resources and the quality and quantity of the output. These actions leave a lasting imprint on the environment (Valdiya, 1987). Quarrying effects can eventually result in larger-scale topographical changes, environmental changes and biodiversity loss. People have used rock as the main component of building material from ancient time. It is essential to implement a comprehensive exploration, exploitation and development plan to boost the value of minerals and rocks. Changes in land resources directly impacts on global environmental change and have become a hot issue among the academicians (Liu et al., 2002).

The geology of Jhansi District is dominated by the Archaean Bundelkhand Gneissic Complex and recent alluvium. Gneisses, silicates, banded magnetite, quartz reefs, ultramafic, tuffaceous, and dolerite dykes are all found in granite. The granite and quartz reef are intruded by dolerite dykes (typically medium grained and dark grey; generally cut across the right angles). Feline and porphyry dykes have also been discovered in Jhansi (Basu, 1986).

Jhansi Tehsil is dominated by tropical deciduous vegetation. Tendu (Diospyros melanoxylon), Babul (Acacia nilotica), Palas (Butea monosperma), Khair (Acacia catechu), Ber (Ziziphus mauritiana), Semal (Bombax ceiba), Kardahi (Acacia arabica) and Mahua (Madhuca longifolia) are some of the plants that grow well in the region. Firewood is harvested from forest and scrub areas for sale and consumption. As per the District profile of Jhansi (Census of India, 2011), farmers' major source of income is agriculture. Agriculture is also reliant on irrigation and soil health. Only 40.76 per cent of net land was irrigated (CGWB, 2008). As a result, agricultural regions rely on rainwater. The water reservoir is necessary since Jhansi is experiencing frequent drought conditions from ancient times, Royal families and people have built little or large ponds to conserve rain/surface water during the monsoon so that the water may be preserved for a longer length of time to meet the demands. Irrigation and drinking water were also provided by these dams/reservoirs. Similarly, soil health is normally determined by soil quality, but in Jhansi, the Vindhyan range's combination of red and black soil is not very productive. The red soil group is separated into 'Rakar' and 'Parwa' based on texture, whereas the black soil group is divided into 'Kabar' and 'Mar'. A more or less uniform aquifer system is formed by the alluvium and the primary weathered zone of granite/gneisses crypt. Alluvium with fine to coarse sand, gravel, pebble, silt, clay, and kankar has a maximum depth of 60 metres due to its quaternary age. As a result (CGWB, 2008), during the Kharif season (July – September), major crops are Sorghum vulgare (jowar) and Cajanus cajan (L.) Mill sp. (toor) and during the Rabi season (November – March) Triticum sphaerococcum (wheat), Cicer arietinum (gram), and Lens culinaris (masoor).

MATERIAL AND METHODS

This study is especially devoted to assess the effect of mining activities on neighbouring environment and to provide an eco-restoration plan for abandoned sites with suitable mitigation measures. The north eastern part of Tehsil Jhansi is primarily underlain by high rank igneous rocks of Bundelkhand cratons, these rocks consist of gneiss and granites etc. hence it is quite suitable for quarry business. The study area is lies between 25° 26' 27.2616'' to 25° 28' 17.5080'' N and 78° 39' 5.1840'' to 78° 41' 49.3008'' E. The total geographical area was calculated as 1532.18 ha by using google earth image (Fig. 1). To evaluate the effect of mining activities, required information on environment and health issues of nearby villagers was recorded by using drafted questionnaire/ personal interviews (Table 1).

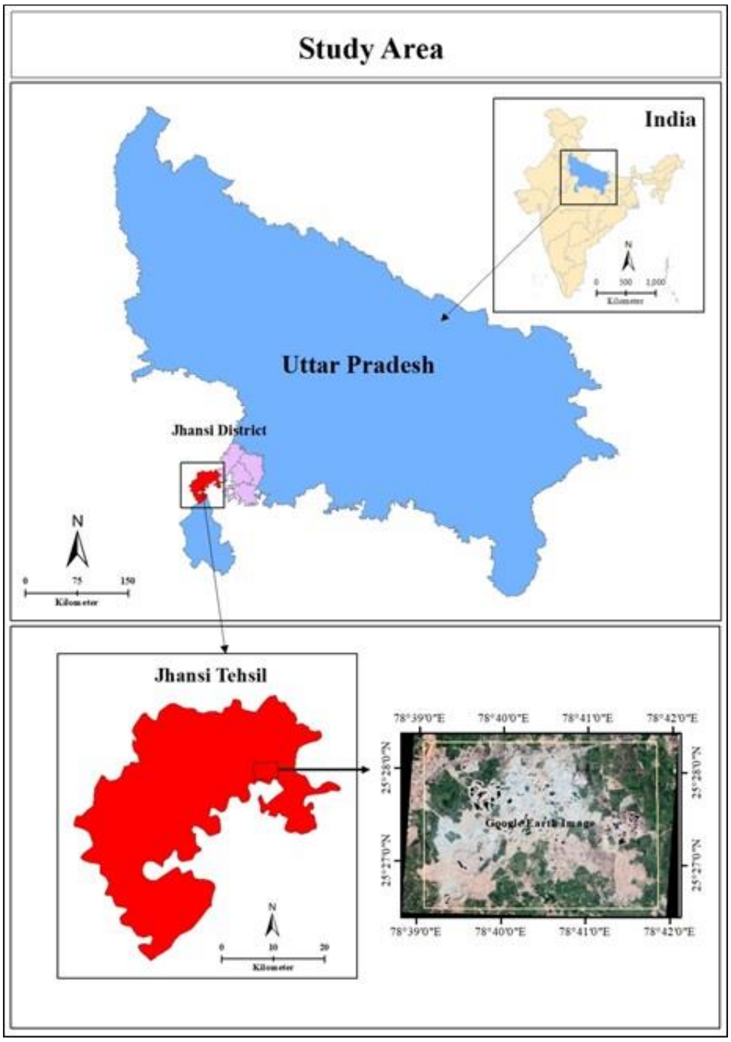

Fig. 1: Map showing study area situated in North-Eastern part of Jhansi Tehsil, Uttar Pradesh, India

Table 1: Drafted questionnaire to evaluate health issues of nearby villager

S. No.	Name	Age	Sex	Village	Occupation	Nearby mining status	Health issues

RESULTS AND DISCUSSION

This study is purely based on questionnaire, personal interaction with the neighbouring villager's and reported documents. The objectives were classified in four categories i.e. 1. Existing state of neighbouring villagers in terms of land resources; 2. Environmental imbalance and eco-friendly changes of neighbouring villagers; 3. Management plan with suitable mitigation measures and 4. Plan for restoration. The details of the designed outcome are as follows –

Existing state of neighbouring villagers in terms of land resources

There are three villages located around the cluster group of mining sites (Fig. 2). These villages, name as Digara, Goramachhiya and Dimroni, are located in the north-eastern part of Jhansi Tehsil, Uttar Pradesh, India. All are situated about 8-10 km from Jhansi city toward Kanpur.

Suitable place for Fig. 2

Demographic outline of villages

The total geographical area of the villages are 1064.63 ha (Digara), 516.47 ha (Goramachhiya) and 465.31 ha (Dimroni). Households are about 609, 185 and 383 in Digara, Dimroni and Goramachhiya respectively. Total population of the villages were recorded as 3383, 964 and 2038 in Digara, Dimroni and Goramachhiya and the average per cent of scheduled caste/ tribal population were 34.34, 29.15 and 45.28 respectively. Total female population recorded in Digara, Dimaroni and Goramachhiya are 1584, 450 and 997 which is 46.82, 46.68 and 48.92 per cent of the total population respectively. Sex ratio (i.e., number of females per thousand males) were estimated as 880.48, 875.47 and 957.73 respectively (Census of India, 2011). On the other hand in the literacy, the number of males was much greater than females. (Table 2 & Fig. 3). Demographic transition encompasses not only a movement from high to low fertility and death rates, but also the evolution of families and aspects of their life cycle (Turner, 1999).

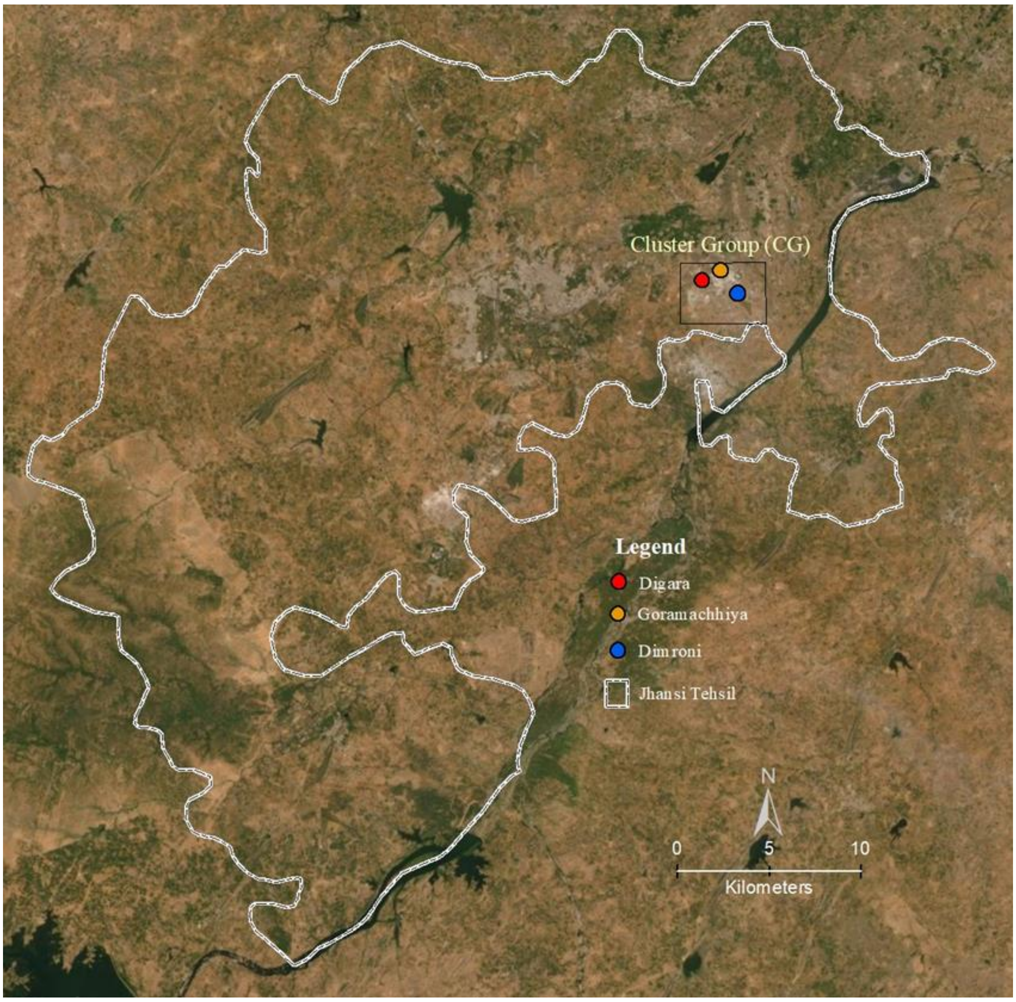

Fig. 2: Geographical location of the villages around the cluster group of mining sites

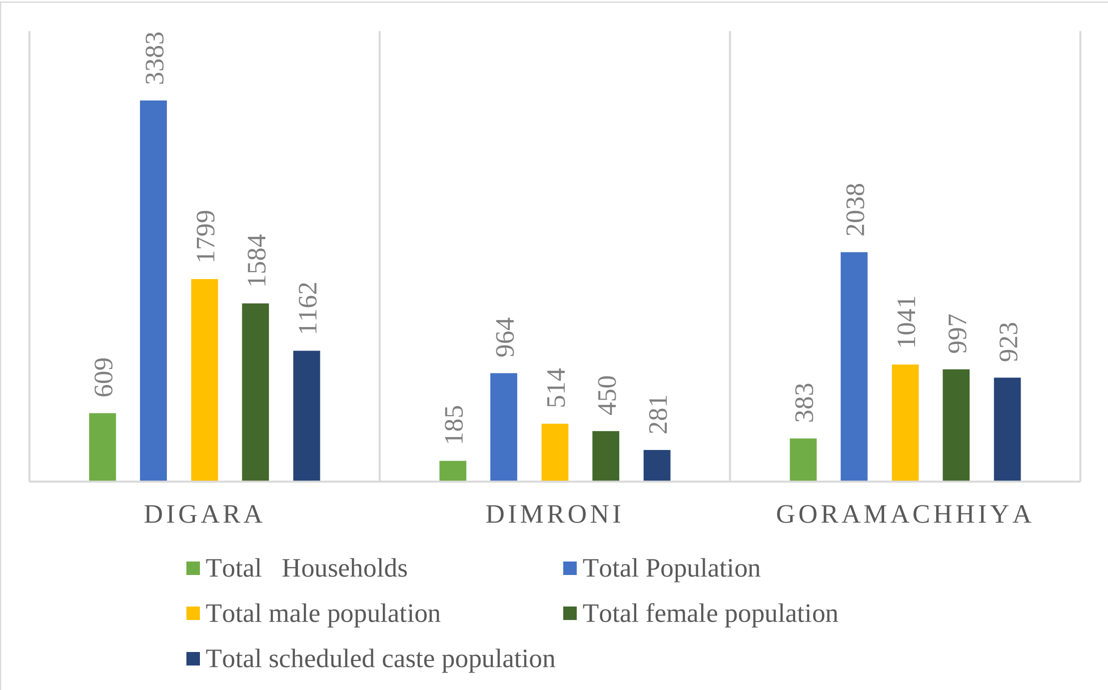

Fig. 3: Demographic profile of the villagers

Table 2: Demographic profile of the villages

Village Name	Digara	Dimroni	Goramachhiya
Total geographical area (in ha)	1064.63	465.31	516.468
Total households	609	185	383
Total population	3383	964	2038
Total male population	1799	514	1041
Total female population	1584	450	997
Total scheduled castes population	1162	281	923

Source: (Census of India, 2011)

Landholding and housing condition

It is evident from the field survey that about 5% land was owned by big farmers (land holding > 10 acres) and about 95% were small farmer's (land holding < 2.5 ha). Due to mining activities, most of the nearby farmer's land were purchased by the mining company owner for stone crushing and dumping purpose. The villages are consequently moving in the direction of a landless/ marginal condition. The another reasons of changing landholding size in past 18 years were stone quarrying and crushing activities because of inappropriate behaviour of cultivation due to mining dust. There are no other option available to holding land for cultivation and other purposes instead of sell them property. Some villagers had transformed a part of their cultivated land for non-cultivated purposes and transform in to commercial/ mining activities. Many villagers have some land which was under barren and uncultivable land and want to construction of houses and water ponds/ tanks for fisheries and to develop small commercial place but they were fail to execute all due to mining activities specially dust cloud shaped by moving of heavy vehicle around. Fig. 4 shows the actual conditions of villager's houses near mining site.

Developed houses after mining site was abandoned

Un-developed house located near active mining site

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Fig. 4: Housing condition near mining activities

Agriculture state

The current of mining activities had a massive impact on agriculture surrounded by the stone quarry (Fig. 5). The main crops grown in the nearby villages were Sorghum vulgare (jowar), Triticum sphaerococcum (wheat), Pisum sativum L. (peas), Vigna mungo (urd) and Arachis hypogaea (groundnut). It was observed that productivity was lower and affected by dust particles fallout. The main reasons for lower yield were reported as lack of productive land with low irrigation and lesser use of fertilizer, pesticide and compost manure etc. Deposited stone dust on soil and crops, deteriorating soil quality and agricultural output. (Prajapati, 2012; Zia-Khan et al., 2015). Farming was not sufficient to involve all the family adults for full time work in agriculture practices hence they are bound to move in search of work as unskilled labour.

Shrinked agriculture land under wheat cultivation   Dust influence around agriculture land

Fig. 5: Current agriculture status near mining sites

Environmental imbalance and sustainable changes of neighbouring villagers

Dust and gaseous contamination

The stone quarrying and crushing activities like drilling, crushing, dumping and transportation etc. produce high quantity of dust which was deposited over a large area of land including plants and nearby vegetation (Fig. 6) and affect human health also. Sharma et al. (2013) stated that open cast mining generates far more trash than underground mining, it pollutes the air significantly (Sharma et al., 2013).


Dust produce by crushing unit


Air contamination caused by mining activities

Stored dust on farmer’s field

Fig. 6: Upended dust and gaseous contamination

Noise pollution

Noise can also effect the plants, animals and human. Quarrying and crushing activities (crushing, grinding, drilling, blasting, loading, transportation etc.) has also been ear-splitting activities (Fig. 7). These activities are all noisy in nature which is not only affect the local environment of the region but also population of the surroundings.

Drilling and blasting

Crushing and grinding

Crushed stone loading in a truck

Transportation

Fig. 7: Noise pollution post produced by mining activities

Livestock situation

Most of the land seems covered with mining waste as which also affects the cattle population. The animal population was recorded negligible in the surrounding villages because the villager has fail to full fill the essential requirement like feed and fodder for animals (Fig. 8). Hence the size of their livestock has decreased by time.

Goat grazing on agriculture land   Stray cows searching fodder near mining site

Fig. 8: Status of animals in and around the mining sites

Health issues of neighbouring villagers

To calculate the impact of mining activities on human health, a questionnaire based survey for 20 participants was conducted to collect the data for various health issues among the people. On the basis of collected information, the result conclude that the concentrated rate of respiratory diseases were observed in comparison with other diseases like chest pain, blood pressure, eye diseases, skin diseases etc. Workers/ labours of mining sites (residents outside the surrounding villages) also face occupational health hazards like anxiety and headaches due to noise/ air pollution and dust. About 50% participants facing multiple diseases, about 15% face single disease and about 35% found healthy (Fig. 9). Out of 20 participants, seven participants have age group of 21 - 30, six have age group of 31-40 and seven have age more than 41. Fig. 10 shows that about 85.71% participants found healthy with age group between 21-30 and maximum respiratory disease found about 66.67% with age group of 31-40 (Table 3). Quarrying and transportation activities produce a lot of waste stone dust, which is a major cause of pollution. The health of mining workers were directly harmed by this stone dust, which makes them vulnerable to life-threatening respiratory disorders such as silicosis, TB and chest pains (Chopra et al., 2012; Yarahmadi et al., 2013; Ahmad, 2014; Solanki et al., 2014).

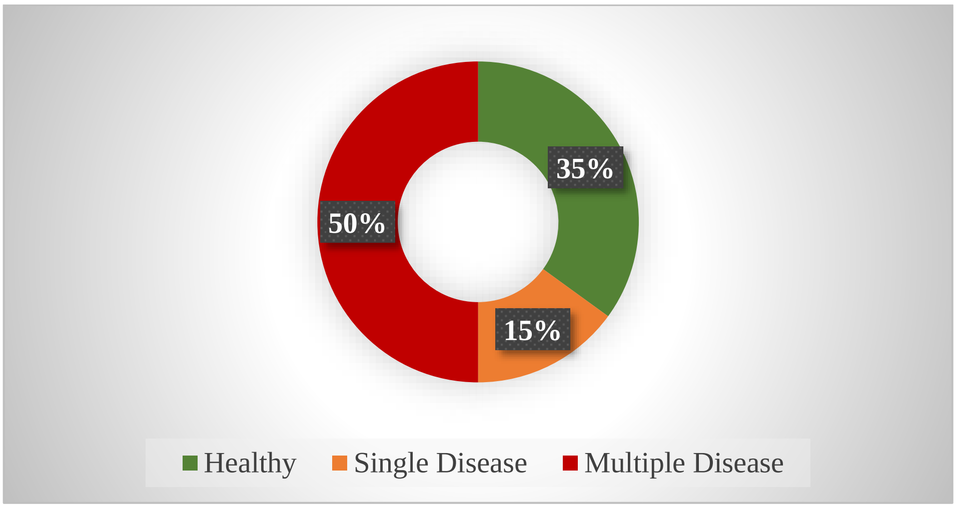

Fig. 9: Health status of nearby villagers

Table 3: Age-group wise health issues of nearby villagers

Health issues	Age group (all)	Age group (21-30)	Age group (31-40)	Age group (>41)
	Out of 20 Participants (%)	Out of 7 Participants (%)	Out of 6 Participants (%)	Out of 7 Participants (%)
Respiratory disease	45.00	14.29	66.67	57.14
Eyes dryness	15.00	0.00	50.00	0.00
Headache	35.00	42.86	33.33	28.57
Stress	5.00	0.00	0.00	14.29
Blood pressure	15.00	0.00	0.00	42.86
Chest pain	5.00	0.00	0.00	14.29
Skin itchiness	5.00	0.00	0.00	14.29
No Health issue Found	35.00	85.71	33.33	14.29

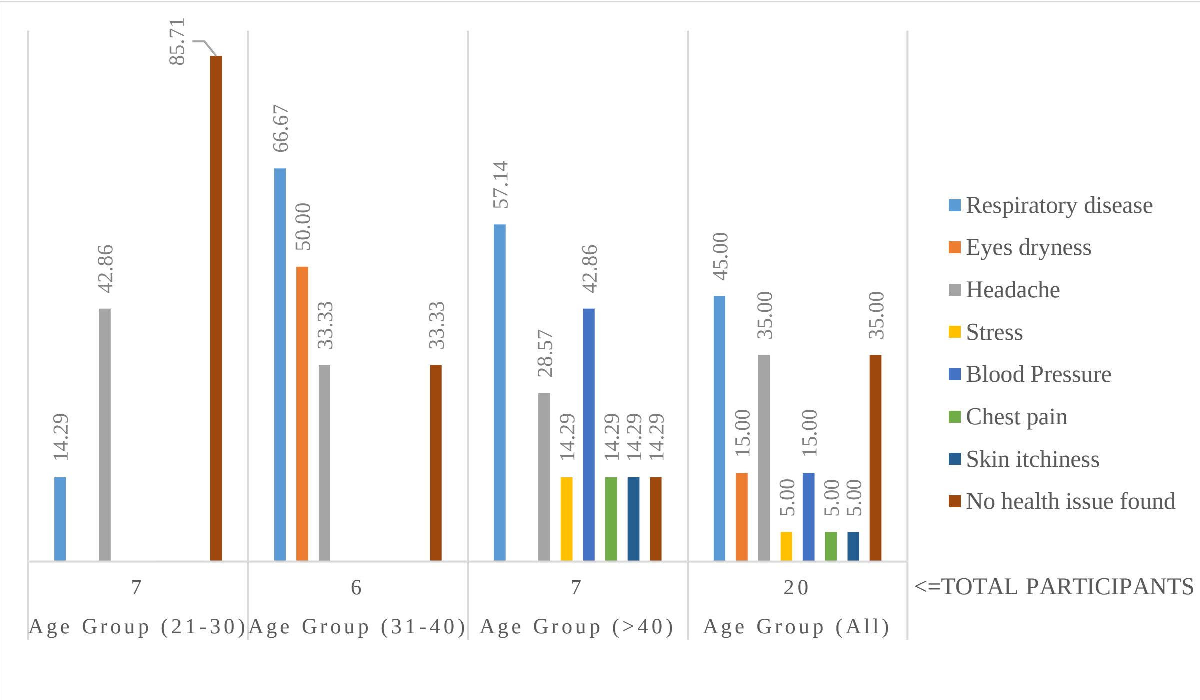

Fig. 10: Age-group wise health issues (%) of nearby villagers

Occupational arrangement

The village has mixed population in terms of financial condition. Some of them has his own land so they are totally depending on farming and some of the villager has involve in the mining activities as per their skills. Hence, some peoples working as truck/ tractor driver and some of them working as labour. In the light of economic conditions, about 60-70% adult male population of nearby villages dependent on mining activities.

Plan for restoration

Abandoned as well as affected quarry areas have potential to be utilized for planting the trees, shrubs and other plants to creating nature trails as well as nature sanctuaries and pasture reserves that can restore the area and enhance its scenic value. Afforestation and other land use systems needs to be taken up. Following technique needs to be followed after above mentioned mitigation measures.

Afforestation

Afforestation of the area with local trees and shrubs should be carried out to restore the abandoned mining sites that will enhance scenic value and to fetch many environmental services. Platforms and staggered slope/ slabs should be planted with indigenous local and multipurpose trees and shrubs. Whereas, slope surface should be planted with the local perennial fodder/ multipurpose grasses and shrubs. Nitrogen fixing herbaceous legumes and shrubby legume species should be preferred to increase the nitrogen levels of soil. Species that can colonize rapidly in the area and have multiple benefits (Fuel wood, fodder, fruits, non-timber forest products etc.) should be preferred. If possible, tree and shrubs seedlings should be inoculated with microbes and bacterial strains to enhance their growth and establishment. Areas around roads/ paths and mining pits should also be planted for re-vegetation by adding soil, organic matter or by creating cemented platforms with indigenous, local and multipurpose trees and shrubs.

Vetiver grass plantation

Vetiver grass (Vetiveria zizanioides) is a substantial viable perennial grass species that may grow well in quarry regions on exposed dry slopes or waterlogged places. When planted as a hedgerow along contour lines, it is good for soil and water conservation since it grows quickly and creates a vast root system (National Research Council, 1993; Truong, 1994). In 1990, a research was undertaken on a series of trials and demonstrations utilising vetiver to reduce soil erosion and restore damaged habitats and the findings were almost always positive (Ao et al., 1993; Xia et al., 1996, 1997). Hence, Vetiver grass may be planted on abandoned and active quarry sites on dry slopes, around mining pits and in wet places (Zhang and Xia, 1998).

Development of nature trails/ wildlife sanctuary

Abandoned mining areas can be converted into nature trails/ wild life sanctuaries by planting diversified annual, perennial herbs, shrubs and tree species that will ensure good cover, food, water and resting as well as roaming places for the wildlife without any disturbances. Planting can be done on stabilized slopes, platforms, around mining pits to attracting the birds and butterflies etc. Large varieties of wild plants bearing beautiful flowers needs to be planted on sites.

Grazing land/ pasture reserve

During the field survey, it has been noticed that the local villagers facing the problem about fodder for their livestock in and around the mining activities. Therefore, here is the proposal for pasture reserve/ grazing land to meet out the fodder demand of local livestock. The abandoned mining area can be easily converted into pasture reserve/ grazing land. There is shortage of fodder in the area especially during summer season due to which livestock are being left by local people for free grazing (locally known as anna pratha) on the roads, which often leads to the destruction of agricultural crops. In this scenario, utilizing mining pits/ depressions areas for pasture/ grassland production can solve the issue of anna pratha and fodder shortage in the locality. Following technique can be utilized for converting the area into pasture reserve. Perennial grasses, herbs, shrubs that are palatable and rich in crude protein, macro and micronutrients should be grown on them. Improved range legumes and grasses usually in the ratio of 2:1 ratio (grass: legume) should be planted to increase pasture quality and yield. Besides this, cutting and harvesting schedule should be decided where grasslands are used for cut-and-carry system. Always rotational grazing has to be followed with some part of pasture with grasses and legumes being left aside for setting and shedding of seeds.

Aqua-cultural practice

Mining pits in abandoned stone quarries are widespread characteristics that might serve as suitable aquaculture locations (McCullough et al., 2020). Aquaculture is one of the potential eco-friendly alternative that can be deployed in mining pits for restoration of quarrying area once it has been abandoned. Moreover, restoration of mined area, aquaculture can be utilized for recreational purpose as a source of food and to boost local economy by employing local youth. For utilizing mining pits for aquaculture, their stored water needs to be tested for any treatments, if required due to presence of heavy metals. Moreover, mining pit shaping or re-contouring can be done to give proper shape to pits. If heavy metals are present in low amount then sport fishing and ornamental fish culturing can be carried out for sale purpose and shorter duration fish cultivation utilizing fast growing fish species or via artificial feeding can be focused upon to reduce heavy metal accumulation in fish. De-silting and cleaning of the mining pits can be carried out to store clean water that can be used for fish culturing. If mining pits are of huge depth making harvesting of the fish impossible, then fish culturing in floating cages of 2m×1.5m×2m to 4m×3m×4m can be carried out which can hold around 100 kg of fish biomass (ICAR-CCARI, 2022).

Rain water harvest

Abandoned/ partially abandoned mining sites having profound quarry pits and have potential to be utilized for harvesting rainwater and also to revive the groundwater aquifers (Darwish et al., 2008). Reshaping of the quarry area, especially large mining pits can be used for harvesting the rainwater that can be place easily to other practice corresponding for drinking water purposes (after treatment of water) and irrigation for neighbouring villagers. Cleaning, de-silting and reshaping of the pits should be accepted for rainwater harvesting. There is shortage of water for daily usage (drinking, bathing, cloth washing and livestock) in and around the mining sites as the river Betwa, which flows in the zone, almost dries up/ lack-off to fulfil the requirement during summers. In this scenario utilizing mining pits for rain water harvesting and to recharge local aquifers is a potential option for confrontation of water shortage. The macrophytes (tree species) can be planting around quarry to breakdown the contamination of the quarry basins.

Management plan with suitable mitigation measures

Stabilizing slopes and creating artificial slopes

Unstable slopes in quarry area needs to be stabilized by cleaning and reshuffling the material, reducing slope angles, creating various levels and staggered slope blocks and adding various platforms as well as sidewalks to each level on the slope.

Backfilling of the mining pits

Debris from mining pits needs to be cleaned and farm yard manure needs to be added to them to facilitate planting of trees/ shrubs.

Adding organic matter on slopes for plantation

Sufficient quantity of organic matter and soil needs to be added on the levels of slope/ platforms etc., so that perennial grasses, herbs, shrubs and ornamental plants can be grown. This will be suitable settings for re-vegetation of the quarry areas.

Protection of quarrying site

Planted site needs to be protected from external disturbances (especially stray animals) till the planted vegetation's get established. Bio-fencing in the form of closely planted bamboo species or thorny local shrubs or barbed wire fencing can be deployed for protection of the vegetation.

During the ground trothing and proper discussion (using drafted questionnaire) with nearby villagers, it was witnessed the causative issues that affect the land resources, environmental imbalance and socio-economic changes of neighbouring villagers caused by mining activities, are land holding, housing condition, agriculture, dust and gaseous contamination, noise pollution, livestock, health issues and occupational arrangements of nearby villager. Dust and noise from SQCA alter existing biodiversity, causing local hydrological and geological regimes to be disrupted (Amitshreeya and Panda, 2012). These activities also affect the substratum, landscape patterns, natural habitat destruction, natural succession, and genetic resources (Ukpong, 2014). Furthermore, increased, mining activities have resulted in various social challenges and conflicts in many parts of the world, including land use issues, socio-cultural survival and community displacement, cultural site damage, self-determination, resource control, and the formation of ghost towns (Nasserdine et al., 2009). With the demands of nearby villagers, First-aid kit and emergency medicines will be kept at quarry site along with contact number of nearby medical facility. The various mining activities like loading/ unloading and vehicle movement include ricks and will have to be accomplished with proper safety norms.

In other hand, "Recovery or restoration of land is also possible with appropriate land-use policies. Consolidation of landholdings and the shift from communal, traditional systems to formal, state-sanctioned regimes is a trend observed throughout the developing world" (McConnell and Keys, 2005). Various activities located near mining sites, which are not fit for agriculture and other land resources, needs to be systematically observed before planning for eco-restoration. For this, socio-economic conditions of people be located in nearby areas should also be considered when development, identification and shaping of mining sites for renovation. Additional, deliberation should be paid to the choice of activities land holder is interested to implement.

The results conclude that the mining/quarry area can be developed through suitable mitigation measures such as stabilizing slopes and creating artificial slopes, backfilling of the quarry pits, adding organic matter on slopes for plantation, protection of quarrying sites and restore the sites by afforestation, vetiver grass plantation, development of nature trails, restoration of grazing land, aqua-cultural practicesand rain water harvesting etc. to avoid environmental imbalance of neighbouring villagers. It is also suggested that remote sensing and GIS/ GPS technique integrated with drone technology may be very helpful for monitoring of mining areas.

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Conflicts of interest

Authors asserted no conflict of interest.

Ethical statement

Authors stated that the study was accompanied according to ethical standards.

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