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Impact of Biodiversity Loss on the Rise of Acute Respiratory Infections Among Inhabitants in Mining Areas of Bolani, Keonjhar District, Odisha

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ABSTRACT

Mining activities in Bolani, Keonjhar district of Odisha have resulted in severe environmental degradation through forest depletion, vegetation loss, habitat disturbance, and increasing air pollution, which may adversely affect respiratory health among nearby populations. Rapid expansion of open-cast iron ore mining has altered the ecological landscape of the region, reduced vegetation cover and weakening ecosystem services such as air purification and dust regulation. This study examined the prevalence of Acute Respiratory Infections (ARI) and its association with environmental degradation and occupational exposure in mining-affected communities.

A cross-sectional study was conducted among 150 households comprising 235 individuals, including mine workers and local residents. Data were collected through household surveys, field observations, and health assessments and analyzed using descriptive statistics, chi-square tests, correlation analysis, and logistic regression techniques. Biodiversity loss and ecological degradation were assessed indirectly through indicators such as visible forest degradation, dust accumulation, reduction in vegetation density, and community perceptions regarding environmental change.

The findings showed that ARI prevalence among surveyed households was 28.43%. A statistically significant association was observed between occupational exposure to mining activities and occurrence of respiratory illness ($\chi^2 = 9.01$, $p < 0.05$). Adults within the 25–45 years age group, particularly females, reported higher incidence of respiratory symptoms. Field observations further indicated that villages located closer to mining sites experienced greater ecological degradation, sparse vegetation cover, and higher dust exposure. Correlation analysis also indicated a positive relationship between environmental exposure and frequency of ARI cases, while lower-income households experienced greater medical expenditure related to respiratory illness. The study concludes that mining-induced environmental degradation, including biodiversity loss, forest disturbance, and prolonged dust exposure, contributes substantially to respiratory health risks in the region. Strengthening environmental regulation, biodiversity conservation measures, workplace safety practices, and community health interventions is essential for reducing ARI burden and promoting sustainable development in mining-affected areas.

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1. Introduction

Mining activities not only alter landscapes but also lead to significant biodiversity loss, ecosystem degradation, and environmental pollution, which ultimately influence human health. Large-scale open-cast mining often results in deforestation, habitat fragmentation, soil erosion, and disruption of local ecological processes, thereby reducing the capacity of ecosystems to regulate environmental quality (Sonter et al., 2018; Grantham et al., 2020). Recent research increasingly highlights the strong interdependence between biodiversity, ecosystem health, and human well-being, indicating that environmental degradation can intensify the prevalence of respiratory and infectious diseases in vulnerable communities (Landrigan et al., 2018). Land-use change and deforestation are frequently associated with increased respiratory illnesses due to higher concentrations of particulate matter and changes in local microclimatic conditions (Brauer et al., 2021). In mining environments, workers and nearby residents are exposed to respirable particulate matter, silica dust, diesel emissions, and other airborne contaminants that can cause airway inflammation, decline in lung function, and various respiratory disorders. Exposure to fine particulate matter (PM), commonly generated during ore extraction, drilling, blasting, and transportation activities, has been linked with cardio-pulmonary impairment and a higher risk of respiratory diseases among mining workers and surrounding populations (Brauer et al., 2016).

Beyond pollution, biodiversity loss itself has important implications for human health because ecosystem degradation weakens the natural regulatory mechanisms that help maintain environmental balance and disease control (Grantham et al., 2020). Changes in biodiversity and ecosystem functioning can influence the transmission and prevalence of infectious and respiratory diseases, highlighting the importance of integrating environmental conservation with public health strategies (Landrigan et al., 2018). Communities residing near mining zones are particularly vulnerable because they often experience simultaneous exposure to environmental pollution, habitat degradation, and socio-economic challenges. These combined pressures can contribute to a higher burden of disease, especially respiratory illnesses such as acute respiratory infections (ARI). In many mining regions, elevated concentrations of particulate matter and other air pollutants frequently exceed recommended air quality standards and are associated with increased respiratory morbidity among nearby populations (Brauer et al., 2016). Evidence from different mining regions also indicates that environmental pollution and ecosystem disturbance caused by mining activities significantly increase the risk of respiratory diseases and other health problems among local communities (Sonter et al., 2018).

These observations underline the importance of examining mining-induced ecological degradation not only as an environmental issue but also as a major public health concern. Understanding the complex interactions between biodiversity loss, environmental pollution, and respiratory disease prevalence is therefore essential for developing effective environmental management strategies and public health interventions.

2. Review of Literature

Environmental pollution and biodiversity degradation have become major global concerns affecting human health and ecosystem sustainability. According to the World Health Organization (2021), exposure to air pollutants such as particulate matter significantly increases the risk of respiratory diseases including acute respiratory infections, particularly in regions with intense industrial and mining activities. Recent global assessments indicate that environmental pollution is responsible for a substantial proportion of disease burden worldwide, with millions of deaths annually attributed to polluted air, contaminated water, and toxic exposures (Fuller et al., 2022). Mining activities, in particular, contribute to environmental degradation through deforestation, soil disturbance, and airborne particulate emissions that adversely affect human health (Landrigan et al., 2020). This indicates a serious need for regular health checkups, health education, use of personal protective devices, and engineering measures for control of the workplace environment. Abraham (2008) highlighted that mining operations disproportionately increase the hardships faced by women, particularly in their roles related to food, water and family health and livelihood management. Zhang et al. (2012) reported that mining and smelting activities adversely affect environmental quality and human health through heavy metal contamination, particulate emissions and ecosystem degradation. Thus, a link between health status and environmental pollution due to mining activities was thus inferred.

Donoghue (2004) has also outlined the physical, chemical, biological, ergonomic and psychosocial occupational health hazards of mining and associated metallurgical processes. Although mining remains an important industrial sector in many parts of the world and substantial progress has been made in the control of occupational health hazards, there remains room for further risk reduction. This applies particularly to traumatic injury hazards, ergonomic hazards, dust particles, toxic gases and noise. Vigilance is also required to ensure effective control to avoid exposures to coal dust and crystalline silica remains.

Mining activities often lead to large-scale land-use changes, forest loss, and environmental contamination that directly impact nearby communities. In India, forest ecosystems are increasingly under pressure from mining expansion and infrastructure development. According to the Forest Survey of India (2024), several mining regions have experienced significant forest cover changes, which can negatively influence local biodiversity and environmental quality. Research by Bebbington et al. (2018) demonstrates that resource extraction and associated infrastructure development significantly threaten forest ecosystems, accelerates forest loss, and adversely affects the rights and livelihoods of local communities, thereby contributing to environmental degradation with potential implications for human health. Such ecological disturbances may increase community exposure to environmental pollutants and contribute to higher incidence of respiratory illnesses among populations living near mining areas. The global assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019) highlights that large-scale ecosystem degradation and biodiversity loss are increasingly linked to declining environmental quality and emerging public health risks. Similarly, global studies indicate that rapid deforestation and habitat degradation reduce ecosystem services such as air purification, climate regulation, and disease regulation, which are essential for maintaining human health (Williams et al., 2020).

Studies indicated that airborne particulate matter generated from mining operations contributes significantly to respiratory health risks among nearby populations (Tian et al., 2019). Air pollution remains one of the leading environmental risk factors for respiratory diseases globally. Studies show that long-term exposure to particulate matter ($PM_{2.5}$ and PM_{10}) significantly increases the prevalence of respiratory infections, chronic bronchitis, and other pulmonary disorders (Brauer et al., 2021). Furthermore, global epidemiological evidence suggests that respiratory infections continue to be a major contributor to the global disease burden, particularly in developing countries where environmental pollution and limited healthcare access exacerbate health risks (Global Burden of Disease Collaborative Network, 2021, Diseases and Injuries Collaborators, 2024).

3. Methodology

The present study adopted a cross-sectional descriptive and analytical research design to examine the relationship between mining-induced environmental degradation, biodiversity loss, and the prevalence of Acute Respiratory Infections (ARI) among residents living in mining-affected areas of Bolani in Keonjhar district, Odisha. The research integrates environmental health assessment and socio-economic analysis to understand how ecological disturbances caused by mining activities influence respiratory health in nearby communities. The study was conducted in the Bolani mining region of Keonjhar district, one of the major iron ore producing areas of India. Geographically, Bolani is located at approximately 22.10°N latitude and 85.37°E longitude, with an average elevation of about 477 metres above mean sea level. The region is characterized by extensive open-cast iron ore mining, forest degradation, and high exposure to mining dust and particulate matter, which potentially affect the health of nearby populations. Several surrounding villages, including Limitur, Lotapani, Gamulai, Kanarda, Gadadharpur, Lasarda, and Bolani township, were included in the study.

A multistage sampling technique was employed to select the study population. In the first stage, the Bolani mining cluster was purposively selected due to the intensity of mining activities, proximity of human settlements to mining sites, and reported respiratory health problems among residents. In the second stage, ten villages located near the mining zone were selected based on distance from mines, population size, and accessibility. In the third stage, households were selected using a systematic random sampling method, and a total of 150 households comprising approximately 235 individuals were surveyed. The respondents included mine workers, agricultural workers, women, children, and elderly residents, ensuring representation of different socio-economic and demographic groups.

Both primary and secondary data sources were used for the investigation. Primary data were collected through household surveys, participatory rural appraisal (PRA) techniques, and health status assessments. A structured questionnaire was used to collect information on socio-economic conditions, occupational exposure, respiratory symptoms, healthcare access, and treatment practices. Participatory tools such as village mapping, group discussions, and key informant interviews were conducted to obtain community-level insights. Health status assessment included information regarding the prevalence of respiratory symptoms and ARI cases reported during the previous year. Secondary data were obtained from government health department records, census reports, Forest Survey of India (2024) documents, district statistical handbooks, mining department records, and relevant published literature.

Softwares used for statistical analysis

The collected data were entered, coded, and analyzed using different statistical software packages depending on the nature of the analysis. Microsoft Excel 2019 was used for preliminary data entry, tabulation, percentage calculations, and preparation of summary tables and charts. Descriptive statistical analysis, including frequency distribution, prevalence rate calculation, and cross-tabulation of demographic variables, was performed using IBM SPSS Statistics Version 26. The Chi-square (χ^2) test used to examine the association between age, gender, and ARI occurrence was conducted in SPSS. Pearson's correlation analysis between per capita income and medical expenditure was also carried out using SPSS.

Binary logistic regression analysis assessing the influence of proximity to mining sites, occupational exposure, and household income on ARI occurrence was performed using STATA Version 14.0. The regression coefficients, standard errors, t-values, and significance levels were generated through STATA statistical outputs. Tables and statistical interpretations were subsequently compiled and verified using Microsoft Excel and SPSS to ensure consistency and accuracy of result

For statistical analysis, collected data were coded and analyzed using descriptive and inferential statistical methods. The prevalence rate of ARI was calculated using the formula:

$$\text{Prevalence Rate} = \frac{\text{Number of ARI cases}}{\text{Total population surveyed}} \times 100$$

to determine the proportion of individuals affected by respiratory infections. To examine the association between categorical variables such as age group, gender, occupational exposure, and ARI occurrence, the Chi-square (χ^2) test was applied using the formula:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

where O represents the observed frequency and E represents the expected frequency. In addition, the relationship between per capita income and expenditure on medical treatment was analyzed using correlation analysis, expressed as:

$$r = \frac{\sum(X-\bar{X})(Y-\bar{Y})}{\sqrt{\sum(X-\bar{X})^2 \sum(Y-\bar{Y})^2}}$$

where r denotes the correlation coefficient, indicating the strength and direction of the relationship between the two variables. Furthermore, binary logistic regression analysis was used to assess the probability of ARI occurrence based on environmental and socio-economic determinants, expressed as:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

where p represents the probability of ARI occurrence, β_0 is the intercept, and $\beta_1 X_1$, $\beta_2 X_2$, $\beta_3 X_3$ represent explanatory variables such as proximity to mining sites, occupational exposure, and household income. These statistical tools helped in identifying the significance of environmental and socio-economic factors influencing respiratory health among residents of the mining-affected region.

4. Results, Statistical Analysis and Discussion

4.1. Biodiversity Loss and Ecological Changes in the Mining Landscape

The Bolani mining region has undergone extensive ecological transformation due to the rapid expansion of open-cast iron ore mining. Mining operations have contributed to forest degradation, vegetation clearance, habitat fragmentation, and land use alteration in surrounding villages. According to reports of the Forest Survey of India (2024), mining-dominated regions of Odisha have experienced noticeable reductions in forest cover and ecological integrity over recent decades. Such environmental disturbances reduce ecosystem services including air purification, dust filtration, soil stabilization, and microclimatic regulation, thereby increasing human exposure to airborne pollutants and respiratory health risks.

Field observations conducted during the present study also indicated substantial environmental degradation in areas located close to mining sites. Respondents reported decreasing vegetation cover, increased dust deposition on agricultural fields and household surfaces, decline in local flora, and deterioration of environmental quality over time. Villages situated nearer to active mining zones exhibited sparse tree cover and higher levels of suspended particulate matter compared to relatively distant settlements. These ecological disturbances are consistent with patterns of biodiversity loss commonly associated with mining-induced land-use change and habitat destruction.

Although the present study primarily focuses on respiratory health outcomes rather than direct ecological measurement, biodiversity loss was assessed indirectly through indicators such as visible forest degradation, reduction in vegetation density, dust accumulation, and community perceptions regarding environmental change. These indicators provide supporting evidence of ecological decline in the mining landscape and help explain the increased vulnerability of local populations to respiratory illnesses.

Previous studies have demonstrated that deforestation and ecosystem degradation caused by mining activities significantly reduce environmental resilience and contribute to declining air quality (Sonter et al., 2018; Grantham et al., 2020). Loss of vegetation and ecological buffers may intensify the dispersion of mining dust and particulate matter, thereby increasing the prevalence of respiratory infections among nearby communities. Thus, biodiversity loss and environmental pollution should be understood as interconnected processes influencing both ecosystem sustainability and public health in mining-affected regions.

I. **Common Respiratory Diseases and their symptoms observed**
   1. Common Cold: Symptoms include sneezing, stuffy nose, runny nose, sore throat, coughing, mucus dripping down the throat, watery eyes and sometimes fever which require medical attention
   2. URTI: Symptoms commonly include cough, sore throat, runny nose, nasal congestion, headache, low grade fever, sneezing, and myalgia.

II. **Causes for Common Respiratory Diseases**
   The prime causes for respiratory disorders are found to be smoking and air pollution, allergies, viralinfections, bacterial Infections and miscellaneous factors like autoimmune disorder, inflammation etc.

III. **Susceptible Groups for Developing Respiratory Diseases**
   Susceptible groups for contracting respiratory infections were investigated to be Individuals with a family history of heart disease, senior citizens, people having cardiovascular diseases, small children and people with long term exposure to air pollution

IV. **Diagnostic tests followed for diagnosis of respiratory diseases:**
   Imaging test: X-rays and CT scan, Lung function test, blood tests,

V. **Common cure without medical aid followed at Bolani**
   1. Improvement of air quality at home like avoiding accumulation of clutter,
   2. Adopting healthy lifestyles like practicing breathing exercises, pranayam, managing stress, etc.
   3. Adopting Home remedies like use of essential oils, avoiding alcohol, caffeine, intake of anti-inflammatory foods, etc

VI. **Common cure with medical aid followed at Bolani**
   1. Use of common respiratory medicines to treatbreathing shortness, COPD, fibrosis, asthma.
   2. Use of antimicrobial medications to treat microbial infections
   3. Use of corticosteroids to reduce respiratory inflammations
   4. Use of bronchodilators to reduce congestion of respiratory passage
   5. Using both short acting and long acting beta antagonists
   6. Use of mucolytics like Pulmozyme and Acetylcysteine
   7. Use of suitable antibiotics for treating acute cases of pneumonia and bronchitis
   8. Use of supplementary oxygen cylinders as and when needed.

The collected data from 150 households comprising 235 individuals in the Bolani mining region were coded and analyzed using both descriptive and inferential statistical techniques to assess the prevalence of Acute Respiratory Infections (ARI) and the influence of environmental and socio-economic factors on respiratory health.

Table 1. Gender distribution of population in Bolani As per 2011 Census.

Location/Villages	Male	Female	Total
Limitur	132	156	288
Lotapani	81	95	176
Gamulai	135	129	264
Kanarda	193	204	397
Gadadharpur	80	90	170
Lasarda	392	399	791
Bolani	1079	1115	2194
Camp of Bolani	244	177	421
Kiriburu	910	859	1769
Dhanurjayapur	767	768	1535
Kolhapandoli	140	140	280

4.2. Working population in Bolani

In Bolani block, out of the total population, 6340 were engaged in work activities,78% workers are mines workers for more than 6 months, 22% were involved in marginal activities providing livelihood for less than 6 months.

Table 2. Gender wise work population in study area.

Categories	Male	Female	Total
Main mines workers	4332	616	4948
Cultivators	46	12	58
Agriculture laborers	49	5	54
Cottage industries	96	17	113
Marginal workers	887	505	1392
Others	4141	582	4723
Non-workers	5086	8567	13653

4.3. Income Analysis in Bolani Block of Keonjhar District

The income source of people in the study area is mines and agriculture, but most of people depend on mining. Monthly Income of mine worker is divided into 4 categories.

The table shows that most of people come under the first category of income i.e. between Rs 5000–Rs. 10000. It was 62%. Only 3% people lies in the income group Rs 20000–25000. 45 people that are 30%, earn Rs 10000–Rs. 15000 per month and 8 people lies in the income group Rs. 15000–Rs.20000.It is clear from the table that income of mine worker is not sufficient to compensate their expenditure on treatment.

Table 3. Income slab of working population in study area.

Income from Mining (Rs.)	No. of Households working in Mines
5000–10000	93 (62%)
10000–15000	45 (30%)
15000–20000	8 (5%)
20000–25000	4 (3%)

4.4. Age and Gender Distribution of ARI

The distribution of ARI cases across different age groups and gender was analyzed. The results showed that female respondents (120 cases) were slightly more affected than males (115 cases). The highest number of cases was recorded in the 25–45 years age group, particularly among females (66 cases), followed by the 12–25 years age group. This pattern suggests that adults in the productive age group experience higher exposure to environmental pollutants and occupational dust.

To test whether the distribution of ARI across age groups and gender was statistically significant, a Chi-square (χ^2) test was applied using the formula:

$$\chi^2 = \sum (O - E)^2 / E$$

where O represents observed frequencies and E represents expected frequencies.

The calculated Chi-square value was χ^2 (3, N = 235) = 9.01, p = .029, and the p-value was 0.029. Since the p-value is less than the significance level of 0.05, the results indicate a statistically significant association between age group, gender, and ARI occurrence. This implies that demographic characteristics influence the vulnerability of individuals to respiratory infections in the study area.

Table 4. Diseases and their percentage occurrence reported in the study area.

Disease	No. of Individuals	% of disease(representing multiple illness per person)
Malaria	168	40.48
ARI(Acute Respiratory Infection)	118	28.43
Water Borne Diseases	60	14.46
Fever	40	9.63
Typhoid	19	4.6
Blood Pressure	5	1.20
TB	3	0.73
Jaundice	2	0.48

Table 5. Occurrence of ARI in different age groups in Bolani.

Different age groups	**Males affected**	**Females affected**
5–12 years	14	11
12–25 years	40	30
25–45 years	41	66
45–65 years	20	13
Total	115	120

Above data indicates that adult females in the age group between 25–45 years are mostly affected with ARI.

Health of all the members of the family is studied by asking question regarding the health problem they have in the last one year. Accordingly, scores were given. Families who have person suffering from common diseases like Malaria, ARI, Water borne Diseases like loose stool, cholera and diarrhea etc. are 40.48%, 28.43% and 14.46% respectively. Families having persons' suffering from severe diseases like TB, Blood pressure are below 5% and such families come in the average category. In families, when the members do not suffer from any major disease come under fair group.

4.5. Relation between Expenditure on Treatment and Per Capita Income

Expenditure on treatment is directly related to per capita income of a mine worker, where poorer households spent proportionately more because of repeated illness burden. The persons working in mines and living within or surrounding mines suffers from various diseases. They have also not sufficient income to mitigate their expenditure on treatment of their family.

Expenditure on treatment	coefficient	Standard Error	t	p > t
p-value	−.0228444	.0133523	−1.71	0.089
Constant	7784.458	290.5498	26.79	0.000

This indicates that expenditure on treatment is negatively correlated with per capita income. p value is 0.089 which is significant at 10% significant level.

4.6. Correlation between Income and Medical Expenditure

To understand the socio-economic dimension of health vulnerability, the relationship between per capita income and expenditure on medical treatment was analyzed using Pearson's correlation coefficient, calculated as:

$$r = \left[\sum (X - \bar{X})(Y - \bar{Y})\right] / \sqrt{\left[\sum (X - \bar{X})^2 \sum (Y - \bar{Y})^2\right]}$$

The analysis yielded a correlation coefficient (r) of −0.42, indicating a moderate negative relationship between income and healthcare expenditure. This suggests that households with lower income levels tend to spend a relatively higher proportion of their earnings on medical treatment due to frequent illness and limited preventive healthcare access.

4.7. Logistic Regression Analysis

To further examine the influence of environmental and socio-economic variables on ARI occurrence, a binary logistic regression model was applied using the equation:

$$\log(p/(1-p)) = \beta_0 + \beta_1 X_1 + {}_2X_2 + {}_3X_3$$

where

p = probability of ARI occurrence
β_0 = intercept
X_1 = proximity to mining sites
X_2 = occupational exposure to mining dust
X_3 = household income.

The regression results indicated that proximity to mining areas and occupational exposure to mining dust were significant predictors of ARI occurrence, while household income showed a moderate but meaningful influence on disease vulnerability. Individuals living closer to mining operations or working in mining-related activities exhibited a higher probability of developing respiratory symptoms compared to those residing farther from mining sites.

The findings of the present study showing a high prevalence of acute respiratory infections among residents in the Bolani mining region are consistent with previous research indicating that mining-related dust exposure significantly contributes to respiratory morbidity (Entwistle et al., 2019).

Additionally, the observed environmental degradation and forest loss reduce ecosystem services such as air purification, climate regulation and ecological resilience, thereby increasing human vulnerability to environmental health risks (Williams et al., 2020; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019).

5. Conclusion

The present study highlights the significant relationship between mining-related environmental degradation and the occurrence of acute respiratory infections (ARI) among communities residing in the Bolani mining region of Keonjhar district, Odisha. The findings reveal that respiratory illnesses are widely prevalent among the local population, with adult females in the age group of 25–45 years being particularly vulnerable, possibly due to combined exposure to environmental pollutants and household conditions. Residents commonly reported symptoms such as sneezing, nasal congestion, running nose, persistent cough, sore throat, headache, low-grade fever, and breathing difficulty, which are typical indicators of upper respiratory tract infections. The study indicates that open-cast mining activities contribute significantly to dust pollution, which is a major environmental factor associated with respiratory health problems. In addition to mining dust exposure, other contributing factors such as smoking habits, environmental pollution, seasonal allergies, and viral infections further increase the risk of ARI among the affected population.

The application of statistical tools such as prevalence rate calculation, chi-square test, and regression analysis helped in identifying the significance of environmental and socio-economic factors influencing respiratory health among residents of the mining-affected region. The statistical results indicated a meaningful association between variables such as proximity to mining sites, occupational exposure to dust, and income levels with the prevalence of respiratory diseases. These findings suggest that both environmental conditions and socio-economic vulnerabilities play a crucial role in shaping the health outcomes of communities living near mining operations.

The study also observed that many residents rely on traditional and non-pharmaceutical remedies, including breathing exercises, yoga, pranayama, and herbal preparations, often without formal medical consultation. Overall, the results demonstrate that villages located in close proximity to mining operations experience higher incidences of respiratory illnesses, emphasizing the environmental health consequences of large-scale mining activities. While mining contributes to regional economic development, its environmental and public health implications cannot be overlooked. Therefore, the study underscores the need for stronger environmental regulations, improved dust control measures, regular health monitoring, and community awareness programs in mining-affected regions. Policymakers and mining authorities must adopt sustainable mining practices and ensure effective enforcement of environmental safeguards to reduce pollution exposure and protect the health and well-being of local communities.

CRediT statement

J.M-Investigation, Writing Original draft, Data Analysis Editing and Supervision

Declaration of competing interests

The author declares that she has no known competing financial interests or personal relationships that could influence the work reported in this paper.

AI-use disclosure statement

During the preparation of this manuscript, the author used AI tools to improve the language and readability. After using this tool, the author reviewed the content and made changes wherever necessary. The author takes full responsibility for the contents of this publication.

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