Impact Assessment of Mining Activities on Surface and Sub-Surface Water Condition of Ramgarh, Jharkhand, India using Geospatial Techniques

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1. Introduction

The mining activities disturb the equilibrium of the ecosystem, which causes an adverse effect on the precipitation trends [3]. The high insulation coverage due to heavy deforestation causes a significant thermal rise in the area. This phenomenon further results in the reduction of the moisture content, which ultimately affects the cloud formation process [3, 4]. A huge decrease in the green cover creates an imbalance in the evapotranspiration rate, which directly affects the local precipitation trend [1-3]. The changing hydrological behavior and its frequent alarming trends are one of the major aspects, where a quick and innovative approach is required.

The extensive mining operations make an aggravation in the subsurface seepage framework. These disturbances incorporate a condition that brings down the ground water table of the area. The insoluble coal dust released from the mines starts to settle down at the base of the local repositories (lakes, wells, ponds, etc.), which displaces the percolation capacity, and ultimately reduces the ground water level of the area [3, 4]. A deep excavation generally disturbs the natural subsurface arrangements, which changes the relocation of groundwater streams [4].

The organic aerosols released from the coal mines have been found to have a significant impact on the cloud formation and the condensation processes [7]. The study based on the interactions between the cloud formation and the aerosol emission in the warm season of central east China has concluded that the aerosols (black carbons) are responsible for the enhancement of atmospheric stability, which further results in the depression of upward motion of evaporation and...
consequently affects the precipitation process [10].

The mining industry is a noteworthy financial movement, which contributes fundamentally to the economy of India. India has the 5th biggest coal reserves in the world. The states like Jharkhand, Odisha, Madhya Pradesh (M.P), Chhattisgarh, West Bengal (W.B), Telangana, and Maharashtra are having the abundant coal beds in their vicinity. They share about 98.26% of the total known coal reserves in India. Ramgarh is one of the major coal abundant districts of Jharkhand that has been chosen for the case study analysis.

This work briefly investigates the impact of expanding the mining activities over the changing rainfall and ground water trends of Ramgarh. The objectives of this work include (1) Quantification of the topographic variations observed by comparing the LULC maps of the study period; (2) A comparative study of the rainfall trend through the TRMM maps with a special focus on the mining prone areas; (3) The ground water trend analysis and the study of the variations observed in the water table using the Mann-Kendall test and Sen’s slope estimations.

2. Materials and methods

2.1. Studied Area

Ramgarh was carved out of the erstwhile district of Hazaribagh on 12th September 2007. The district is situated between the 23° 25’ 30” N - 23° 58’ 00” N latitude and the 85° 12’ 00” E - 85° 53’ 00” E longitude, having an area of 1343.68 km². It is a part of Chotanagpur Plateau that comes under the zone of Damodar Basin/Rift. Due to the varied hydro-geological characteristics, the ground water potential differs from one region to another. The area is mostly covered under the red soil, which provides a suitable condition for the growth of rice, wheat, pulse, oilseed, and maize. There is a huge temperature difference in this area. It has been recorded up to 40°C (104°F) during summers and 10°C (50°F) during the winters. The Ramgarh district entails six blocks, namely Gola, Ramgarh, Mandu, Chitarpur, Patratu, and Dulmi (District survey report of stone district-Ramgarh, 2018).

2.2 Data collection

Land use/cover: For the LULC classification, the Landsat satellite data was downloaded from the official website (earthexplorer.usgs.gov) of the United States Geological Survey (USGS). Each satellite image represents the dry season. The Landsat 8 and Landsat TM-5 data of the base year (2007) and the end year (2018) was used for the analysis.
Precipitation data: The TRMM 3B43 dataset was used for the rainfall trend analysis. The monthly rainfall datasets were collected from the website of https://giovanni.gsfc.nasa.gov for the period of 2007-2018. The 3B43 dataset is the monthly dataset. The product was generated using the adjusted TRMM microwave-infrared precipitation rate (mm/h) and the Root-Mean-Square precipitation-error estimates. It provides an accurate precipitation estimation in a latitude band covering 500 N to 500 S under the growth of the TRMM section from all the universal datasets like high-quality microwave data, infrared data, etc.

Ground water data: The pre-monsoonal (June) and post-monsoonal (October) ground water data (2007-2018) for Ramgarh was used for the trend analysis. The data was obtained from the official portal of Central Groundwater Board.

2.3 Classification and evaluation of land use/cover

In order to evaluate and classify the land use pattern through LULC, the supervised classification methodology with the maximum likelihood algorithm was used. The maximum likelihood algorithm (MLC) is a standout amongst the most well-known directed grouping strategies utilized with remote sensing system techniques. This strategy depends on the likelihood that a pixel has a place with a specific class. The essential hypothesis accepts that these probabilities are equivalent for all classes and that the info groups have typical disseminations [8]. In any case, this technique requires a prolonged stretch of time of calculation, depends vigorously on an ordinary circulation of the information in each info bands, and tends to over-group marks with generally expansive qualities in the covariance framework.

The land use/cover was analyzed by classifying the area into 7 classes, namely barren land, fallow land, crop land, forest cover, mining area, settlement area, and water body. The obtained maps of 2007 and 2018 were compared according to the percentage change observed in their land use area for the detailed analysis.

![Figure 2. Land use/cover map of year 2007.](image-url)
2.4 Rainfall trend analysis using TRMM 3B43 data

The rainfall trend analysis of Ramgarh was carried out using the TRMM 3B43 annual accumulated rainfall datasets (processed by the monthly dataset values). The datasets were recorded for the 7 raster location points (Mandu (upper and lower regions), Patratu, Gola, Dhubmi, Chitarpur, and Ramgarh) of the district, under which every block was covered individually for the analysis. The datasets were processed in order to obtain the precipitation maps under Arc-GIS. These precipitation maps were further classified under the different rainfall intensity zones mentioned in Table 1.

Table 1. Zone classification of precipitation map.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Precipitation zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Lowest rainfall</td>
</tr>
<tr>
<td>Yellow</td>
<td>Low rainfall</td>
</tr>
<tr>
<td>Green</td>
<td>Moderate rainfall</td>
</tr>
<tr>
<td>Sky blue</td>
<td>High rainfall</td>
</tr>
<tr>
<td>Navy blue</td>
<td>Highest rainfall</td>
</tr>
</tbody>
</table>

2.5. Ground water trend analysis

**Mann-Kendall Test:** The Mann-Kendall test is a non-parametric strategy utilized for pattern investigation of time arrangement information. The significant preferred standpoint of this test is that it is free from the factual conveyances that are required for the parametric techniques [5] [6] [9]. The null hypothesis (H0) for the Mann-Kendall test is that there is no pattern or sequential connection amongst the broke down populace against the elective speculation (H1) that accepts the expanding or diminishing monotonous pattern. The Mann-Kendall statistic (S) is given as:

\[
S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn (X_j - X_i)
\]  

where (S) is the Mann-Kendall’s measurement, and (sgn) is the signum work. The above pattern test is done for a period arrangement \(X_i\) that is positioned from \(i = 1, 2, \ldots n-1\) and \(X_j\), which is again positioned from \(j = i+1, 2, \ldots n\). For each one of the evidence points, \(X_i\) is taken as a kind of perspective point that is differentiated, and the remainder data focuses on \(X_j\) so that:
\[ sgn(X_j - X_i) = \begin{cases} 
1 & \text{if } (X_j - X_i) > 0 \\
0 & \text{if } (X_j - X_i) = 0 \\
-1 & \text{if } (X_j - X_i) < 0 
\end{cases} \] (2)

On the off-chance that \( n < 10 \), at that point estimation of \(|S|\) is contrasted straightforwardly with the hypothetical dissemination of \( S \) inferred by Mann and Kendall. At a particular likelihood level, \([H0]\) is dismissed for \([H1]\) if the total estimation of \( S \) rises to or surpasses a pre-defined estimation \( S_{a/2} \), where \( S_{a/2} \) is the smallest \( S \) that has the likelihood not exactly \( a/2 \) to show up if there should be an occurrence of no pattern. A progressive estimation of (S) shows a rising pattern, and the reverse estimation demonstrates a descending pattern [7] [10]. For \( n = 10 \), the measurement \( S \) is coarsely circulated with the mean value of \( E(S) = 0 \) and difference \( (Var. (s)) \). The change measurement is specified as:

\[ Var. (S) = \frac{n(n - 1)(2n + 5) - \Sigma t_i(i)(i - 1)(2i + 5)}{18} \] (3)

Here, \( t_i \) is assumed as the quantity of estimation for test 1. In this strategy, the nearness of a factually huge pattern is assessed utilizing the \( Z_C \) esteem.

\[ Z_C = \left( \frac{S - 1}{\sqrt{Var. (S)}} \right) \text{ if } S > 0 \]
\[ Z_C = 0 \text{ if } S = 0 \] (4)
\[ Z_C = \left( \frac{S + 1}{\sqrt{Var. (S)}} \right) \text{ if } S < 0 \]

A positive estimation of \( Z_C \) shows an expanding pattern, and a negative estimation demonstrates a diminishing pattern. The measurement \( Z_C \) is typically conveyed. In order to examine the escalating and the diminishing monotonous pattern, a two-followed investigation at \( \alpha \) dimension of criticalness was utilized. The invalid or null theory of \([H0]\) is excluded if the outright estimation of \( Z_C \) is more noteworthy in comparison with the \( Z_{(1-\alpha/2)} \), where the \( Z_{(1-\alpha/2)} \) value is attained from the ordinary dispersion tables. In this examination, \([H0]\) that is the null hypothesis denotes that there is a non-pattern scenario regarding the time arrangement of the groundwater level, where \( \alpha \) is the dimension of immensity for the trial. For this assessment, \( \alpha \) and \( Z_{(1-\alpha/2)} \) were taken as 5% and ±1.96, separately. A positive estimation of \( Z_C \) demonstrates an expanding pattern, and a negative esteem shows a diminishing pattern. The measurement \( Z_C \) is typically dispersed.

**Sen’s Slope Estimator Test**: The genuine slant in time arrangement information (change per unit time) is evaluated through the strategy depicted by Sen (1968) assuming the event that the pattern is straight. The extent of pattern is anticipated by the Sen’s slope estimator value \((Q_i)\).

\[ (Q_i) = \frac{X_j - X_k}{j - k} \text{ for } i = 1, 2, \ldots, N \] (5)

\( X_j \) and \( X_k \) are the data values with times \( j \) and \( k \) (here it is assumed that \( j > k \), respectively). The median obtained from the calculation of these \( N \) values is represented as the Sen’s estimator \((Q)\).

The value of \( Q_{med} = Q_{N+1/2} \) when \( N \) is odd, and \( Q_{med} = Q_{N/2} + Q_{(N+2/2)/2} \) if \( N \) is even. The positive value is obtained for the \((Q_i)\) point toward the rising trend whereas the negative value of \((Q_i)\) shows a decreasing trend in the given time series.

### 3. Results and discussion

#### 3.1. Land use/cover status

The topographical variation witnessed during the study period of Ramgarh was evaluated by comparing the land use/cover (LULC) maps of 2007 and 2018. The area was divided into seven different classes: barren land, crop land, fallow land, forest, mining area, settlement, and water body. The detailed evaluation of each class is recorded properly. The drastic change in the land use pattern under these 12 years (2007-2018) can be clearly observed from Figures 2 and 3. The retrieved map of the year 2007 shows more green spots (forest cover) and less black spots (mining area) in comparison with the map of the year 2018. The expanding mining region in the black spot and the deteriorating forest cover in the green spot can be clearly seen under the map of the year 2018. The fluctuations observed in the land use pattern under the different classes from 2007 to 2018 are detailed under Table 2.
Table 2. Data showing area differences occurring under following categories of land use/cover from 2007-2018.

<table>
<thead>
<tr>
<th>Topographical features</th>
<th>2007 Area (in Km²)</th>
<th>Area (in %)</th>
<th>2018 Area (in Km²)</th>
<th>Area (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barren land</td>
<td>233.36</td>
<td>17.37</td>
<td>368.75</td>
<td>27.44</td>
</tr>
<tr>
<td>Crop land</td>
<td>179.75</td>
<td>13.38</td>
<td>148.26</td>
<td>11.03</td>
</tr>
<tr>
<td>Fallow land</td>
<td>308.92</td>
<td>23.0</td>
<td>156.92</td>
<td>11.67</td>
</tr>
<tr>
<td>Forest</td>
<td>519.21</td>
<td>38.64</td>
<td>368.19</td>
<td>27.40</td>
</tr>
<tr>
<td>Mining area</td>
<td>35.41</td>
<td>2.64</td>
<td>182.55</td>
<td>13.58</td>
</tr>
<tr>
<td>Settlement</td>
<td>58.40</td>
<td>4.35</td>
<td>104.57</td>
<td>7.78</td>
</tr>
<tr>
<td>Water body</td>
<td>8.63</td>
<td>0.64</td>
<td>14.43</td>
<td>1.07</td>
</tr>
<tr>
<td><strong>Total area</strong></td>
<td><strong>1343.68</strong></td>
<td><strong>100</strong></td>
<td><strong>1343.68</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The important facts revealed under the analysis are as follow:

- The mining area has enormously increased from 2.64% to 13.58% in just 12 years with an expansion rate of approx. 12.26 km²/year.
- A net increase of 10.95% in the mining area has critically affected the agricultural and forest cover of the Ramgarh district.
- The area under the barren land has been increased with 135.39 km² over these 12 years.
- Area under forest, crop land, and fallow land has been drastically decreased with the percentages of 11.24%, 11.31%, 2.34%, respectively.
- A minor increase in the water body and settlement areas has been observed with a percentage value of 0.43 and 3.44, respectively.

3.2. Precipitation trend analysis

The precipitation trend of the studied area was evaluated by processing the 3B43 TRMM data under Arc GIS. The raster to point conversion of the image was used to obtain the annual rainfall values of the seven selected location points of the district. The rainfall values were evaluated and compared graphically. The yearly rainfall map of 2007-2018 was prepared in Arc GIS, shown under Figures 4-15. These maps were used for the detailed investigations.
Figure 5. Annual precipitation map of Ramgarh district of year 2008.

Figure 6. Annual precipitation map of Ramgarh district of year 2009.
Figure 7. Annual precipitation map of Ramgarh district of year 2010.

Figure 8. Annual precipitation map of Ramgarh district of year 2011.
Figure 9. Annual precipitation map of Ramgarh district of year 2012.

Figure 10. Annual precipitation map of Ramgarh district of year 2013.
Figure 11. Annual precipitation map of Ramgarh district of year 2014.

Figure 12. Annual precipitation map of Ramgarh district of year 2015.
Figure 13. Annual precipitation map of Ramgarh district of year 2016.

Figure 14. Annual precipitation map of Ramgarh district of year 2017.
The yearly rectified TRMM image shows that there is a continuous average to low rate of the rainfall occurring specially in the regions where mining activities exist. The mines are mainly situated in the lower mandu, ramgarh, and bhurkunda blocks of the district. Through the rainfall maps, it was observed that the mining areas were recorded with lesser rainfall values in contrast to the other regions of the district. The annual average precipitation data obtained for the selected location points is shown in Table 3.

Table 3. Average Annual precipitation data obtained from TRMM raster to point calculation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mandu (Upper region)</th>
<th>Mandu (Lower region)</th>
<th>Bhurkunda</th>
<th>Ramgarh</th>
<th>Chitarpur</th>
<th>Dulmi</th>
<th>Gola</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>1437.281</td>
<td>1589.904</td>
<td>1437.362</td>
<td>1435.905</td>
<td>1535.483</td>
<td>1548.361</td>
<td>1618.71</td>
</tr>
<tr>
<td>2008</td>
<td>1447.005</td>
<td>1350.916</td>
<td>1383.103</td>
<td>1375.270</td>
<td>1329.247</td>
<td>1410.727</td>
<td>1409.68</td>
</tr>
<tr>
<td>2009</td>
<td>972.513</td>
<td>923.719</td>
<td>972.494</td>
<td>1093.716</td>
<td>1136.317</td>
<td>1207.509</td>
<td>1183.13</td>
</tr>
<tr>
<td>2010</td>
<td>1168.004</td>
<td>1152.096</td>
<td>1165.472</td>
<td>1202.304</td>
<td>1291.963</td>
<td>1205.503</td>
<td>1304.23</td>
</tr>
<tr>
<td>2011</td>
<td>1608.545</td>
<td>1542.375</td>
<td>1651.321</td>
<td>1603.518</td>
<td>1612.697</td>
<td>1704.795</td>
<td>1682.76</td>
</tr>
<tr>
<td>2012</td>
<td>1260.167</td>
<td>1233.11</td>
<td>1302.343</td>
<td>1314.293</td>
<td>1287.573</td>
<td>1351.933</td>
<td>1372.44</td>
</tr>
<tr>
<td>2013</td>
<td>1381.329</td>
<td>1452.355</td>
<td>1508.859</td>
<td>1446.810</td>
<td>1505.739</td>
<td>1495.275</td>
<td>1559.44</td>
</tr>
<tr>
<td>2014</td>
<td>1161.208</td>
<td>1174.979</td>
<td>1138.178</td>
<td>1110.919</td>
<td>1071.927</td>
<td>1119.55</td>
<td>1116.07</td>
</tr>
<tr>
<td>2015</td>
<td>1161.269</td>
<td>1172.568</td>
<td>1217.614</td>
<td>1240.433</td>
<td>1216.81</td>
<td>1315.033</td>
<td>1338.99</td>
</tr>
<tr>
<td>2016</td>
<td>1215.495</td>
<td>1209.585</td>
<td>1216.774</td>
<td>1248.847</td>
<td>1234.079</td>
<td>1264.026</td>
<td>1227.08</td>
</tr>
<tr>
<td>2017</td>
<td>1306.568</td>
<td>1273.912</td>
<td>1427.047</td>
<td>1475.755</td>
<td>1449.366</td>
<td>1582.551</td>
<td>1560.69</td>
</tr>
<tr>
<td>2018</td>
<td>1090.7</td>
<td>1049.464</td>
<td>1177.505</td>
<td>1218.14</td>
<td>1285.08</td>
<td>1336.172</td>
<td>1396.66</td>
</tr>
<tr>
<td>Average (excluding 2008 and 2014)</td>
<td>1260.187</td>
<td>1259.909</td>
<td>1307.679</td>
<td>1327.972</td>
<td>1355.511</td>
<td>1401.116</td>
<td>1424.413</td>
</tr>
</tbody>
</table>
Some interesting key results found from the analysis are as follow:

- The Lower Mandu, Ramgarh, and Bhurkunda blocks that are the prime mining areas of the district have constantly been seen under the least rainfall zones (red and yellow zones).
- The rainfall map of the years 2008 and 2014 shows an exception in the trend by recording the higher rainfall values under the Mandu, Ramgarh, and bhurkunda blocks (i.e. sky blue and navy blue zone).
- After analyzing the precipitation values, it was found that the mining active regions show a relatively lesser rainfall values (except in the year 2008 and 2014) in comparison with the non-mining areas under each individual year.
- The differences in the decadal average precipitation between the mining (Mandu with the value of 1260.187 mm/y) and non-mining zones (Gola with 1424.413 mm/y) can be clearly seen in the above tabular data.

3.3 Analysis of groundwater trend using non-parametric test

The results obtained from the Mann-Kendall test were utilized in order to set up the patterns according to the periodic arrangements of the pre- and post-monsoonal groundwater levels of the area. This test relates the comparative magnitudes of data rather than the data values itself. The statistics of this test is not required to be checked for any further precision. If the value of Z is negative and the value of Z− statistic is greater than the z−value analogous to 5% level of significance, then the trend obtained is found to be negative. Likewise, if the Z value is positive corresponding to 5% level of significance, then the trend is observed as an increasing one. The Mann-Kendall test delivers a kind of trend statistic (Z) that indicates the monotonous rising (positive z) or falling (negative Z) trend. If the P value is < 0.05, then it tells that there is (monotonic) trend, and if τ is +ve, it shows an increasing trend and vice versa. A p value > 0.05, shows a non-monotonic trend. For evaluation of the groundwater trend using the pre- and post-monsoonal data of the different blocks of Ramgarh, the Mann-Kendall test and the Sen's slope estimation were conducted. The deviations observed in the values of z, s, p, τ, and Qi for the pre- and the post-monsoon water levels of each block of Ramgarh are detailed in Tables 4 and 5.

### Table 4. Blockwise details of Mann-Kendall’s Statistic and Sen’s slope estimator for pre-monsoon and the post-monsoon groundwater levels.

<table>
<thead>
<tr>
<th>Block</th>
<th>Pre-monsoon</th>
<th>Post-monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Z</td>
<td>Sen’s slope Qi (m/year)</td>
</tr>
<tr>
<td>Gola</td>
<td>-1.099</td>
<td>-0.1058</td>
</tr>
<tr>
<td>Mandu</td>
<td>1.7143</td>
<td>0.1025</td>
</tr>
<tr>
<td>Patratu</td>
<td>-1.3029</td>
<td>-0.1813</td>
</tr>
<tr>
<td>Ramgarh</td>
<td>-1.44</td>
<td>-0.17321</td>
</tr>
</tbody>
</table>

(*The Statistical significant value at 5% level of significance, ↑ means an increasing trend and ↓ means a decreasing trend.)*

### Table 5. Parameters evaluated to analyze variation in groundwater level trend using Mann-kendall and Sen’s slope estimator.

<table>
<thead>
<tr>
<th>Block</th>
<th>Pre-monsoon</th>
<th>Post-monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S-value</td>
<td>p-value</td>
</tr>
<tr>
<td>Gola</td>
<td>-17.0</td>
<td>0.27</td>
</tr>
<tr>
<td>Mandu</td>
<td>26.0</td>
<td>0.086</td>
</tr>
<tr>
<td>Patratu</td>
<td>-20.0</td>
<td>0.19</td>
</tr>
<tr>
<td>Ramgarh</td>
<td>-22.0</td>
<td>0.14</td>
</tr>
</tbody>
</table>

From the non-parametric evaluations, it has been found that:

- The negative value of τ observed in Gola, Patratu, and Ramgarh has generated a decreasing ground water trend with a value
of -0.26, -0.30, and -0.33. The ground water level has deteriorated sharply under these areas.

- The positive $\tau$ value of the Mandu block in its pre-monsoon period as 0.39 and post-monsoon period as 0.04 specifies an increase in the groundwater level.
- The Z value for Gola, Patratu and Ramgarh in the pre-monsoon season as -1.997, -1.303, and -1.44 and in the post-monsoon season as -0.754, -1.375, and -1.577 also indicates a decreasing ground water trend.
- The Mandu block with its positive Z values of 1.714 and 0.138 in its pre-monsoon and post-monsoon period only shows an increasing trend scenario.

4. Conclusions

The case study of Ramgarh revealed some of the interesting evidences that explained the role of expanding mining activities and its direct or indirect influences over the hydrological conditions. The study period observed a drastic change in its land use pattern. The alarming growth of the mining areas with the rate of 12.26 km$^2$ per year is a huge matter of concern. The decreasing rainfall values under the mining zones (Lower Mandu, Ramgarh, Bhurkunda) are the clear indication that may establish a possible relationship between these two factors. The non-parametric test (Mann-Kendall test and the Sen’s slope estimator) also observed a negative trend in the ground water level under the mining prone areas of the district. The continuous reduction in forest cover, fallow land, and crop land was somehow seen as the factor responsible for the degraded ground water capacity in this area.

Hence, a comprehensive conclusion can be inferred from the results obtained that the mining operation can have a possible impact over the rainfall and the ground water patterns. The gradual expansion of mining might be one of the reasons behind the changing precipitation and ground water trends in these areas. In order to resolve such issues, a proper blue print was prepared by the joint consent of the environmentalists and the government must be required to balance the environment and the economy side by side.

Some suggestive measures that may be taken to counter the risk in the future are as follow:

- Afforestation practices in the dump sites of the mines.
- Lack of metrological data has always been a concern for the impactful research, and hence, proper steps regarding the data storage should be taken.
- Strict legal provisions regarding the emissions of pollutants should be implemented on the local mining industries.
- Revision and strengthening of the carbon credit policy is a requirement of the hour.
- More research work should be carried out in order to study the severe mining impacts on the hydrological parameter using the accurate data.

The issue of mining hazard and its correlation with the hydrological cycle was tried to rise under this article. There are very few research works in this field, and hence, some more relevant studies and stronger evidences are required for the accurate and better understanding of such relationships in the future.

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ارزیابی تأثیر فعالیت‌های معدنی بر وضعیت آب‌های سطحی و زیر سطحی رامگار. جارکند، هند با استفاده از تکنیک‌های Geospatial

چکیده:

این پژوهش تأثیر معدن‌کاری گسترده بر روند بارندگی و وضعیت آب‌های زیرزمینی منطقه رامگار در 12 ساله (1387-1398) بر روی آب‌های سطحی و زیر زمینی دهد. این برای پیشگیری از اثرات قطعی بر روی آب‌های سطحی و زیر زمینی ضروری است. این پژوهش به منظور مقایسه نطفه‌های ArcGIS تحت پوشش سطحی LULC، با روند بارندگی لندsat TM و LAndsat 8 پردازش شده بین 2 کلاس طبقه‌بندی دنبال و پایه است. نتایج نشان داد که در سال‌های 1387-1398، مناطق معدنی به‌طور قابل توجهی کاهش یافته و در تغییرات بهتر، افزایش آب‌های سطحی و زیر زمینی رامگار شده است.

کلمات کلیدی: کاربرد پوشش زمین (LULC)، ArcGIS، TRMM 3B43

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