



DARK PATCHES OF COALTOPIA: DEGRADATION OF PHYSICAL LANDSCAPE BY MINING IN THE RANIGANJ COALFIELD

¹Surajit Bhattacharyay, ²Milli Acharya, ³Subhajit Ghatak, ⁴Sanat Kumar Guchhait

¹Research Scholar

²Assistant Professor

³Research Scholar

⁴Professor

¹Dept of Geography, The University of Burdwan, W.B., India

Abstract

Raniganj Coal Field (RCF), the first coal mining region of India, has faced massive defacement of the physical and cultural landscape due to extensive coal excavation for approximately 250 years. Initially, open cast mining in Raniganj Coal Field (RCF) was started with rudimentary technology during 1774-1830. However, considering the slope of the coal belt underground coal mining has been established for more than two centuries. At present, unauthorized mining has grown up stupendously since the middle of the 1980s through the depillaring of underground peats and rapid extension of bore-hole/rat-hole mining at the peripheral areas of authorized mining sites, mainly in the agricultural tracts. Thus, almost the entire region is transformed into derelict land depicting widespread degradation of topography, and groundwater, dried-up of soil, destruction of primary succession, and modification of relief. Thus, defaced topography is termed 'coal-topia', studied through narrative analysis, word cloud, and Principal Component analysis (PCA).

Index Terms: Ranigang Coal Field, Authorized mining, Unauthorized mining,

Degradation, Physical landscape, EIA

1. INTRODUCTION

Every physical and cultural landscape has a distinct characteristic image and it is also true for the mining landscape. The mining regions of both the developed and developing world depict a different scenario than other resource regions commonly associated with the degraded environment and society (Bell & York, 2012; Goswami, 2015; Gupta & Paul, 2015; Rocha-Nicoleite, Overbeck & Müller, 2017). The coinage of the words 'Dark patches of Coaltopia,' is, therefore, self-reflexive in focusing on the core idea of this paper, i.e., the degradation of the physical landscape of the Raniganj Coal Field in the context of the coal mining landscape of the developing world.

One can easily perceive the distinct image of the Raniganj coalfield traversing the area with the experience that few people in the morning are carrying a bicycle with six to seven bags of coal with the weight of about 5-6 quintals systematically arranged over the bicycle and observing the security personal they run away leaving the coal and the bicycle, or middle-aged men and women are placing the coal bags in the train and paying some money to some persons (collectors in favour of TTE, they said). The history of authorized and unauthorized coal mining in the Raniganj area is as old as 250 years. Since the very beginning of the colonial period, the physical landscape of this area is haphazardly dissected and the cultural landscape is marked by extensive social pathology by the widespread coal excavation in the form of open-cast and underground mines.

Apart from authorized mining, deserted Open coal peats are available in Egara, Pandabeshwar, and Sripur under the Asansol subdivision from where people are collecting coal and making the surface of those areas vulnerable to subsidence day by day. Further, the mushrooming of borehole mining from the middle of the 1980s as an outcome of job sickness due to the nationalization of coal have derelict the land and society in different dimensions. Such degraded natural and social landscapes (Ahirwal & Maiti, 2022) can easily be termed 'Coaltopia'.

The word 'Topia' is related to the image of a topography. Coaltopia, therefore, signifies the image of a coalmining region. Degradation of the physical landscape and defacement of society in the coal mining region of developing countries are more intense for the development of a parallel coal economy (Lahiri-Dutt, 1999; Bharti, Pal, Pathak, Kumar & Ranjan, 2016; Lahiri-Dutt, 2016; Maji & Malik, 2021). In this context, Raniganj Coal Field (RCF), the oldest coalfield in India, has experienced rapid growth of unauthorized mining from 1774 to 1980 and especially after 1980. The mushrooming growth of the unauthorized mining in the old pit and borehole/ rat hole coal peat has extensively and indiscriminately developed in the agricultural field of the western part of this region. The whole operation is a secret process with huge employment and income opportunity. Consequently, such operation with the popular proverbial outlook of 'more the production, more is the profit' ultimately leads to the unaccounted money flow in the market with the subsequent development of social pathology in the form of drug and wine addiction (Lahiri-Dutt, 1999; 2016). This indiscriminate cutting of coal both by authorized and unauthorized mining leads to the derangement of the underground aquifer, uprooting of flora and fauna from the ground, formation of micro-relief due to subsidence, etc. Thus, a derelict land and society have been developed within the last 200 years of this region-the core area of this inquiry.

2. CONCEPTUAL FRAMEWORK

Coal is not only the most important mineral resource for industry and thermal power stations (Mongillo, 2011), but it is the backbone of the economy of Chotanagpur and the key factor for the urban industrial growth of Chotanagpur region (Sinha, 1988; Fernandes & Thukral, 1989; Pati, 2004; Kumar & Kumar, 2015). Contextually, Raniganj and Jharia, the two oldest coalfields of India, are the denominator in propelling the industrial growth of this region. More importantly, Raniganj, in this vein, has occupied the most prominent

spot in the history of coal mining in India (Lahiri-Dutt, 1999; 2016). The historical record shows that the first coal mining was started in the Raniganj area in 1774 by Heatly and Summer to excavate coal from a large area around Sitarampur (Balfour, 1885; Paterson, 1910; Ghosh, 1977; Singh, 2006; Griffiths, 2019). However, local people were familiar with coal as black wood before the excavation in 1774. Practically coal is available in this region at a depth of 7-10 feet and rural people discovered this while digging out ponds for household water requirement.

The pioneering venture by Heatly and Sumner was, however, stopped after one year as the quality of the extracted coal does not meet the required standards of the East India Company (Blanford 1861; Markham, 1878), though there are some confusions about this claim due to some political interest of the British Parliament and the commercial interest of British coal lobby (Blanford 1861). Later on, Mr. Rupert Jones, an eminent engineer of the canvas factory of Howrah opened a mine in Egara Village in 1815, three Km away from Raniganj Municipal office nearby the bank of Damodar (Taly, 1971; Hunter et.al., 1876; Chakrabarti, 1996; Lalvani, 2016; Kling, 2023). Taking a lease of 40 acres of land from the Rani of Burdwan, the operation continued up to 1833. Thereafter, Coal excavation was continued and the hiking of the production was experienced from 1830 onwards (Hunter et. al., 1876; Kripalini, 1981; Kling, 2023). Before, the nationalization of coal mines in 1971, coal excavation was done by the private authority. Since the 1970s most of the mines have come under Government control (Chakrabarti, 2002; Dam, 2014; Bhattacharya, 2019). With the proliferation of coal mining over the last 240 years coal has shaped the economy and society of the Asansol-Durgapur Industrial region. Along with formal mining, non-formal coal mining or unauthorized coal mining has proliferated since the 1980s as the common people are not able to attach with formal coal mining under the Government. Therefore, unauthorized mining and its transportation and trading have experienced stupendous growth.

This parallel economy of coal was prevalent before the nationalization of coal (1971), but the nationalization policy made stronger growth of unauthorized coal mining (Lahiri-Dutt, 1999; 2016). Coupled with the parallel coal economy, social pathology has become an integral part of society in the form of coal crime, unauthorized mining sites, employment through illegal mining, dropout among male school-going students, earning through land lease, addiction among the workers, etc. Everyone believes that coal is responsible for the economic growth and prosperity of this region.

3. STUDY AREA

The study area is the entire Raniganj coal field. Geographically, Raniganj Coal Field (RCF), the first and the most renowned coalfield in India is the backbone of the economy of West Bengal as well as Eastern India. The coal and coal economy has shaped this into a developed urban industrial complex of India, which is considered the second most prosperous urban industrial region of West Bengal.

It is located in the westernmost part of the Bardhaman district of West Bengal, it covers an area of about 1526 sq. km. (earlier 1260 sq. km. but now extended to Murguma of Jharkhand and also to a little extent of Mejia of Bankura district, West Bengal), With an extension from 23°33'N to 23°53'N latitude and from

86°27' E to 87°23' E longitude. The whole area can be marked clearly by prominent natural boundaries, the Damodar, the Ajoy, and the Barakar Rivers on the south-north and west respectively. The eastern boundary may be marked by the Andal-Sainthia railway line. The entire area of RCF is divided into eleven colliery areas namely, Pandeveswar, Jhanjra, Bankola, Kajora, Kunustoria, Satgram, Sripur, Salanpur, Sodpur, Kenda, Sonepur Bazari (Fig.1).

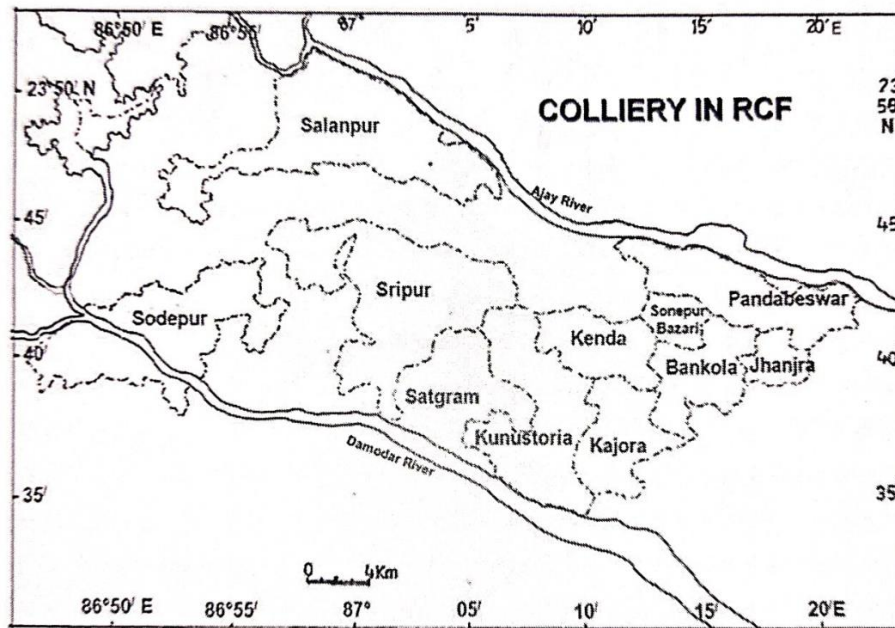


Fig.1: Location map of the study area

4. METHOLOGY

Environmental impact assessment is not a new idea for the assessment of the degradation of the environment, but rather a very popular technique for the analysis of coal mining areas. Different authors have done the environmental impact assessment with different approaches and methods but all the techniques have a unified goal to glean out the negative and the positive impact on the environment for a particular project, human activity, or anti-environmental approach. Choudhury (1992) has discussed widely the theoretical perspective of environmental assessment for coal mining where he elaborated the methodology and procedures of environmental impact assessment. K. Lahiri Dutta (1999; 2016) has widely investigated the environmental impact of coal mining in a narrative way that considers both the physical and social impact of coal mining. Her lucid analysis of social impact through statement is undoubtedly valuable addition from which present consequences and outcomes in the future can be perceived widely. But the present study and methodology concerns, the relative ranking and weightage of different mining activities, and components of physical and social environment based on which scores have been assigned for different variables which will objectively judge the environmental impact of coal mining in RCF.

The objective of this inquiry is to find out or to detect the following impact by mining operations:

- 1) damage to the environment;
- 2) intensity and response of different variables;
- 3) role of the variables for the degradation of the physical landscape.

Keeping all these three objectives in mind, the foregoing analysis put emphasis on Environmental Impact Assessment also opts for all these three objectives i.e., how the negative impacts of authorized and unauthorized coal mining have drastically damaged the physical environment. Hence, the major variables responsible for the damage to the physical environment are properly detected and relatively judged through qualitative and quantitative analysis.

To delve deeper into the degradation of the physical landscape statement analysis and word cloud have been applied based on the narratives and opinions of the respondents of that area. Major areas of degradation of the landscape have been chalked out through these qualitative techniques. Hence, for quantitative analysis, a rating scale of degradation is adopted taking the different variables of the physical landscape. For multivariate analysis, a suitable data matrix is formed by multiplying the relative rating with a variable multiplier as adapted by Chaudhary (1992). The multivariate analysis through PCA can assess the role of the variables and also the spatial nature of degradation.

5. RESULTS AND DISCUSSIONS

Results and discussion of the present research have been allocated in the present section categorically. For better understanding and clarity of the works, here, both the findings and related discussions of each technique are represented under separate sub-headings- narrative analysis, word cloud analysis, and Principal Component Analysis (PCA).

5.1 Narrative Analysis

Narrative analysis is an important tool in social research to understand the basic perspective of natural or social phenomena of an area taking the response from the residents of that area (Riessman, 1993; Kim, 2015). Here altogether 37 responses have been collected who put their response about the physical and social degradation of the landscape. Keeping aside the social degradation only physical degradation is considered for analysis relating to the theme of this inquiry. Three such responses are given below. In this regard, the title of the respondents, age, sex, and their residential identity are mentioned keeping aside the full name of the respondents concerning research ethics.

We had 22 ponds in our Kanyapur village... those were regularly used for domestic use and irrigation. However, almost all are now dried. The water of a few ponds is degraded. Unauthorized mining in the abandoned Barmundia colliery nearby our village may be a cause of this dryness of the surface. Subsidence has occurred in different parts.

Tewari (M,51), of Asansol Kanyapur village

Agricultural lands were everywhere around our village. Now only three people practice Farming. The problems are shortage of water and labour. Previously, we had ponds for irrigation, but now all are dried up or the water is degraded. Surface soil moisture is getting drier for the last two decades due to unauthorized mining. Drylands are full of shrubs and thorny plants.

Mr. Sutradhar (M, 37), Gopapurl village of Sreepur

Subsidence due to unauthorized mining is caused generally by two reasons. One is the de-pillaring of galleries in the abandoned legal underground mines approached by unauthorized miners. The same thing may happen in areas of excessive rat-hole mining. And the other is subsidence due to the aftereffect of a mine fire. Dryness of the surface is a major issue in R.C.F. Large aquifers are not so much disturbed by unauthorized mining but ponds and water-bodies are affected badly.

Mr. Roy (M, 52) retired officer, E.C.L Satgram

The nature of degradation of the physical landscape can easily be perceived from most of the narratives. The above three narrative analysis is no exception to this. Unauthorized mining has caused subsidence, dried up of soil, cutting of aquifers, and also mine fires in several places. Depillaring is the main cause of subsidence due to unauthorized mining. All these factors have severely affected agricultural land and production. With the decreasing intensity of agriculture young generation is gradually tending towards activity related to unauthorized mining. Not only agriculture is affected, but the surface water source is also drastically reduced. Luxurious vegetation has been affected drastically due to the clearing of forest modification of relief, and shrinkage of groundwater. Secondary succession is also detected by the respondents in the form of shrubs and bushes. Therefore, agricultural plots and forested areas are now crowned with scattered shrubs and bushes. A total defacement of the physical landscape can easily be detected by a researcher while visiting the area in the sequel to the responses of the residents.

5.2 Word Cloud Analysis

The word cloud is a surrogate of narrative analysis taking the keywords of narratives or statements that strengthen the analysis (Neüff, 2018). In the present context, keywords about the negative impact of authorized and unauthorized coal mining in the study area through the statements of the respondents are processed through WORDCLOUD.COM which gives the relative intensity of the nature of degradation of physical landscape stated by the respondents. It is clear from the word cloud that **surface, dry, fire, scarcity, mining, and subsidence** are the major words in the word cloud format, whereas **rat-hole, village, mine, agro-labour, water, dryness**, coming in the next category (Fig-2). Thus, vulnerability is expressed through surface, fire, scarcity, dryness, and subsidence by the process of mining and unauthorized mining.

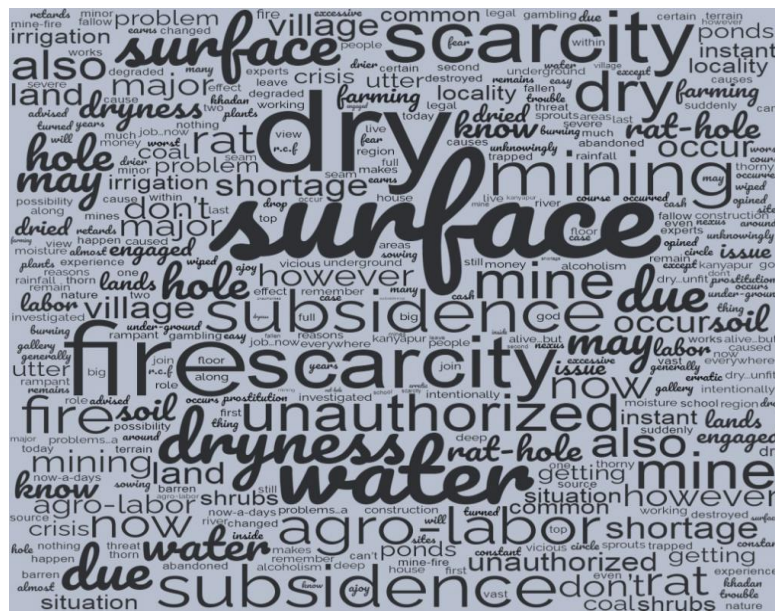


Fig-2: Representation of the keywords of narratives through word cloud analysis

5.3 Multivariate Analysis of Environmental Impact Assessment in RCF

Keeping aside the multiple regression Principal Component Analysis is employed for the linear reduction of variables into factors. Many variables may be considered for physical environmental degradation by mining activity in Raniganj Coalfield, but after a wide field investigation and collecting opinions from the respondents, these five variables have been taken into consideration as they are the fundamental variables and have been frequently marked by the respondents of this area. These five have been treated under Principal Component Analysis, as it is a standardized form of factor analysis that can chalk out the role of different components in the degradation of the system and the nature of degradation in different phases.

The selection of variables is very important in Environmental Impact Assessment, as the variables are the determining factor for the dereliction of the physical and social environment. Here there is no room for environmental pollution in terms of air pollution and contamination of groundwater because all those aspects have been widely investigated by many researchers, at the same time, there are other aspects of the physical environment which are more vulnerable due to mining operations. So, carefully the most vulnerable aspects of the physical and social environment have been taken into consideration to judge the degradation of the physical and cultural landscape of this region. The reasons for the selection of variables are given below.

Together five variables are taken into consideration to perceive the degradation of the physical landscape. The reasons for the consideration of these variables are given below.

X1 – Land Instability: It is the most important as well as the threatening aspect of degradation of the physical environment. Most of the problems of coal mining are concerned with land instability; as it leads to subsidence and, directly or indirectly controls other variables like groundwater, land use, and physiographic inconsistency.

X2 – Groundwater: Though mining operation has a negative impact on soil and land use or change of relief the aspect of groundwater is more vulnerable than other mentioned impacts as both opencast and underground mining truncate the aquifer beyond 20 meters or so; at the same time the opencast mining peats lead to groundwater contamination.

X3 – Soil: Damage to soil is another consideration relating to the degradation of the environment. The importance of soil is undeniable in respect of agriculture and forest. The study area is not characterized by fertile soil but it was very important in relation to forest cover before mining. Clearing of forest is the outcome of mining and damage to trees and shrubs is the result of soil dump, an important outcome of opencast mining.

X4 – Physiography: Physiographic modification is a negative aspect of coal mining, especially in terms of relief modification. The rugged topography by excavation, mining goaf, and mounted soil dumps is the most common scenario in RCF.

X5 – Land use: Land use is the last consideration in investigating the negative impact of mining operations. However, it puts less emphasis on it as land use change in this area is not the outcome of mining only, but also may be due to urbanization and industrialization in terms of negative impact mining surpasses the land use modification than urbanization and industrialization.

Raniganj Coalfield area has been divided into thirteen colliery areas (Fig-1) according to its initial functional consideration. Each area has been graded on a ten-point scale on each aspect of environmental degradation. So, the areas have been ranked from 0 to 10. For example, Sripur has been ranked 10 and Sonapur Bazari is the least rating for open-cast mining only in respect of land stability. These rankings have been worked out after wide investigation, information assimilation, and also consultation with the local people. Components of the physical environment have been ranked similarly on a ten-point scale. The score of the components, thereafter, is defined by the multiplier 25-point bases. With the help of these considerations, the data matrix has been formed (Table 1a) which is treated under Principal Component Analysis (Table 1b, 1c, 1d).

Table 1A: Data matrix for environment impact assessment

| Colliery area | Land instability | Ground water | Physiography | Soil | Land use |
|----------------------|------------------|--------------|--------------|------|----------|
| Sripur | 2000 | 1400 | 875 | 900 | 525 |
| Sodepur | 1600 | 1225 | 875 | 750 | 525 |
| Salanpur | 1400 | 1050 | 875 | 750 | 525 |
| Satgram | 1400 | 1050 | 875 | 750 | 375 |
| Kunustoria | 1200 | 875 | 750 | 600 | 375 |
| Kenda | 600 | 875 | 625 | 450 | 225 |
| Kajora | 600 | 875 | 750 | 450 | 375 |
| Bankola | 200 | 525 | 375 | 300 | 75 |
| Pandaveswar | 400 | 825 | 375 | 750 | 425 |
| Sonepurbazari | 600 | 1050 | 1200 | 1200 | 375 |
| Jhanjra | 200 | 875 | 900 | 1200 | 275 |

Applying varimax rotation initial eigenvalues and rotated component matrix are obtained which are explained subsequently to extract the factors and the role of the variables. First of all, the significance level is judged (Table-1 d). P-value (.000) shows the database is statistically significant and the Chi-square value (Calculated value of 71.366 against the critical value of 21.161 value for 10 degrees of freedom at a level of 5%) confirms that there is a significant difference among the variables which can be reduced into factors (Table 1d). The Eigenvalue of Component-1 is 3.313 with the explained variance of 66.25% and the Eigenvalue of Component-2 is 1.145 with a variance explained of 22.91 % (Table-1b). The third and more than third components are not considered for analysis as the eigenvalues of those components are less than 1.00. The cumulative variance explained is 89.16%. Thus, the two components are sufficient in explaining the degradation of the physical landscape through mining.

Table 1b: Eigen value and variance

| Component | Initial Eigenvalues | | |
|-----------|---------------------|---------------|--------------|
| | Total | % of Variance | Cumulative % |
| 1 | 3.313 | 66.254 | 66.254 |
| 2 | 1.145 | 22.908 | 89.162 |
| 3 | .334 | 6.687 | 95.849 |
| 4 | .148 | 2.961 | 98.810 |
| 5 | .060 | 1.190 | 100.000 |

Table 1c & 1d : Factor loading (1c) & test of significance (1d)

Rotated Component Matrix

| Factors | Component | |
|------------------|-----------|-------|
| | 1 | 2 |
| Land instability | 0.966 | 0.024 |
| Ground water | 0.867 | 0.440 |
| Land use | 0.866 | 0.287 |
| Soil | 0.086 | 0.952 |
| Physiography | 0.351 | 0.843 |

KMO and Bartlett's Test

| | | |
|--|--------------------|--------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .777 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 71.366 |
| | df | 10 |
| | Sig. | .000 |

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Now, looking at the component loading under components one and two, it can be ascertained that the variables that have dominant loadings on component one are land instability (0.966), groundwater (0.867), and land use (0.866). Those are mainly responsible for the degradation of the physical landscape at the first

stage (Table 1c). In the second component (Table-1c), the dominant loadings are soil (0.942) and physiography (0.843). The results show that degradation of the physical landscape firstly affects land instability i.e., subsidence, groundwater, and land use while in the second phase soil and physiography. The results from PCA are slightly different from the view of the respondents. Respondents can easily perceive the visible impact of soil and physiography which have been expressed by the dryness of soil though land use is easily detected by them reflected through the development of bushes instead of luxurious vegetation, dried up ponds in the area shrinking of agriculture. Physiography is another area as uneven topography is easily detected. However, instability of surface or subsidence proneness is not ubiquitous in all the parts of the colliery areas and groundwater damage is difficult to recognize by them. It is true that society easily perceives the surface or superstructure of the phenomena, whereas the deep structure can be realized through deeper investigation. Here, the deep structure of landscape degradation has been detected through PCA.

5.4 Spatial Variation of Landscape Degradation

With the R- mode analysis (variables) the factor score is developed for each colliery area to justify the spatial variation of the derelict surface under those variables. To achieve this perspective, multiple regression is employed for each block by taking the loadings of the five variables and eigenvalues of the first component expressed into a linear equation with the form of

$$Z_{ji} = \beta_{j1} P_1 + a_{j2} P_2 + \dots + \beta_{jn} P_n \dots \dots (i)$$

Where $j=1, 2, \dots, n$ and Z_{ji} is the score of each block,

β_{ji} ($J= 1,2, \dots, n$) is the slope of each variable and a_{ji} is the loading of each variable in each block. Here, only the first component is taken into consideration as the explained variation in it is 66.25% (table 1b). Assessing the factor score-1 with the help of equation (i) spatial variation of land degradation is mapped (Fig-2). The map clearly shows the increasing intensity of physical landscape degradation towards the northeast.

The reason for such degradation can easily be explained. Opencast mining is more common in the northeast

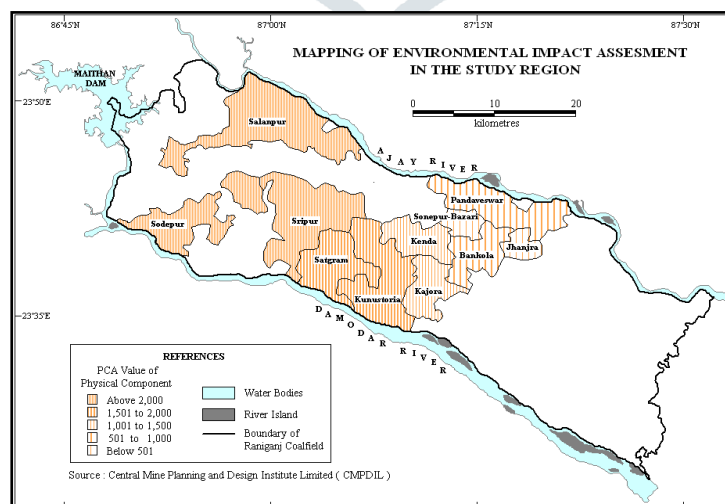


Fig- 2: Degradation of physical landscape

portion developed at the later stages of mining. The initial phase of mining was started mainly in the early ninetieth century through underground mining. Those underground mining sites later on have become lucrative grounds for unauthorized mining mainly from the 1980s due to nationalization of coal mines. Moreover, coal is found at a lower depth in the northwest portion. Unauthorized borehole mining is now extensively practiced in the agricultural areas.

6. FINDINGS

Common people or even learned people have little idea about PCA, by which the land degradation through mining activity can be justified. So, the accumulated idea from the primary and secondary information before PCA analysis and the responses after the analysis almost confirm each other. The finding of this analysis by PCA is a **concrete realization** of this investigation where it can firmly be concluded that dereliction of the physical environment has been highly concentrated in Raniganj, Salanpur, and Jamuria, the core of derelict land. Another important aspect of this impact analysis is the discontinuity of dereliction on physical space. Land surfaces marked by urbanization and industrialization are not so much degraded. The coal mining operation in RCF is indeed confined to the eleven colliery areas. Non-colliery areas are devoid of such dereliction as subsidence, soil dumping, discordant subsurface hydrology, etc. For that reason, most of the rehabilitation planning has been proposed to be located in the non-colliery areas.

7. CONCLUSION

It is already mentioned earlier that the present investigation is an attempt to assess the damage to the physical landscape in RCF through two and half century old authorized and unauthorized mining. The major components of the physical environment have been taken into consideration in assessing the negative impact. The large-scale authorized mining, along with unauthorized mining has extensively damaged topography, soil, and underground water so extensively for long years that there is the least scope for revival. The land dereliction is so extensive that most of the settlements and population within this region are vulnerable. The surface and subsurface are so vulnerable that there is almost no room for revival. Therefore, the High Power Committee has formed in the early middle of the 1980s through legislation after a wider discussion in the Parliament. In the sequel to this, eleven townships have been proposed in the safe areas nearby with the least scope of subsidence but only one plan has been chalked out without implementation due to the problem of budget allocation except the Kanyapur township. It is the need of the hour to implement this programme to avoid the problem of subsidence and resultant vulnerability.

REFERENCES

- [1] Ahirwal, J., & Maiti, S. K. 2022. Restoring coal mine degraded lands in India for achieving the United Nations-Sustainable Development Goals. *Restoration Ecology*, 30(5), e13606.
- [2] Balfour, E. 1885. *The Cyclopædia of India and of Eastern and Southern Asia: Commercial, Industrial and Scientific, Products of the Mineral, Vegetable, and Animal Kingdoms, Useful Arts and Manufactures*. United Kingdom: B. Quaritch.
- [3] Bell, S. E., & York, R. 2012. Coal, injustice, and environmental destruction: Introduction to the special issue on coal and the environment. *Organization & Environment*, 25(4), 359-367.
- [4] Bharti, A. K., Pal, S. K., Priyam, P., Pathak, V. K., Kumar, R., & Ranjan, S. K. 2016. Detection of illegal mine voids using electrical resistivity tomography: the case-study of Raniganj coalfield (India). *Engineering Geology*, 213, 120-132.
- [5] Bhattacharya, A. 2019. *The Rise of Goliath: Twelve Disruptions That Changed India*. India: Penguin Random House India Private Limited.
- [6] Blanford, W. T. 1861. *On the Geological Structure and Relations of the Raniganj Coal Field, Bengla*. India: Government of India.
- [7] Chakrabarti, P. 1996. *Wage-Productivity Relationship in Indian Public Sector*. India: Northern Book Centre.
- [8] Chakrabarti, P. K. 2002. *Investment Decision in Indian Public Sector*. India: Northern Book Centre.
- [9] Dam, S. 2014. *Presidential Legislation in India: The Law and Practice of Ordinances*. United Kingdom: Cambridge University Press.
- [10] Fernandes, W., Thukral, E. G. 1989. *Development, Displacement, and Rehabilitation: Issues for a National Debate*. India: Indian Social Institute.
- [11] Ghosh, A. B. 1977. *Coal Industry in India: Pre-independence period*. India: Sultan Chand.
- [12] Goswami, S. 2015. Impact of coal mining on environment. *European Researcher*, (3), 185-196.
- [13] Griffiths, S. P. 2019. *The British Impact on India*. United Kingdom: Taylor & Francis.
- [14] Gupta, A. K., & Paul, B. 2015. Ecorestoration of coal mine overburden dump to prevent environmental degradation: A review. *Research Journal of Environmental Sciences*, 9(7), 307.
- [15] Hotelling, H. 1936. Simplified Calculation of Principal component. *Psych. vol 1*, 27-35.
- [16] Hunter, W. W., Mackie, A. W., Risley, H. H., O'Donnell, C. J., Kisch, H. M. 1876. *A Statistical Account of Bengal: Districts of Bardwan, Bankura, and Birbhum*. United Kingdom: Trübner & Company.
- [17] Kim, J. 2015. *Understanding Narrative Inquiry: The Crafting and Analysis of Stories as Research*. United States: SAGE Publications.
- [18] Kling, B. B. 2023. *Partner in Empire: Dwarkanath Tagore and the Age of Enterprise in Eastern India*. United States: University of California Press.
- [19] Koshal, A. K. 2000. *Environmental Problems Analysis of Coal Mining in raniganj & Asansol Block (West Bengal) using Remote sensing and GIS*. Hydrabad: Map World Forum, GIS Development.
- [20] Kripalani, K. 1981. *Dwarkanath Tagore: A Forgotten Pioneer, a Life*. India: National Book Trust, India.
- [21] Kumar, D., Kumar, D. 2015. *Management of Coking Coal Resources*. Netherlands: Elsevier Science.
- [22] Lahiri-Dutt, K. 1999. State, market and the crisis in Raniganj coal belt. *Economic and Political Weekly*, 2952-2956.
- [23] Lahiri-Dutt, K. 2016. The diverse worlds of coal in India: Energising the nation, energising livelihoods. *Energy Policy*, 99, 203-213.
- [24] Lahiri-Dutta, K. 2001. *Mining and Urbanization in the Raniganj Coalbelt*. Calcutta: The World Press Private Limited.
- [25] Lalvani, K. 2016. *The Making of India: The Untold Story of British Enterprise*. United Kingdom: Bloomsbury Publishing.
- [26] Maji, G., & Malik, U. S. 2021. An Analysis of Financial Performance of the Coal Mining Industries: A Case Study of Raniganj Coalfield of Eastern Coalfield Limited. *Asian Journal of Economics, Business and Accounting*, 21(8), 1-16.
- [27] Markham, C. R. 1878. *A Memoir on the Indian Surveys*. United Kingdom: W.H. Allen and Company.
- [28] Mongillo, J. F. 2011. *A Student Guide to Energy [5 Volumes]*. United States: ABC-CLIO, LLC.
- [29] Myers, J. L., & Well, A. D. 2003. *Research Design and Statistical Analysis*. New Jersey: Lawrence Erlbaum Associate Publishers.
- [30] Neüff, M. 2018. *Words of Crisis as Words of Power: The Jeremiad in American Presidential Speeches*. Netherlands: John Benjamins Publishing Company.

- [31] Pati, J. 2004. Media and Tribal Development. India: Concept Publishing Company.
- [32] Riessman, C. K. 1993. Narrative Analysis. India: SAGE Publications.
- [33] Rocha-Nicoleite, E., Overbeck, G. E., & Müller, S. C. 2017. Degradation by coal mining should be priority in restoration planning. *Perspectives in ecology and conservation*, 15(3), 202-205.
- [34] Rogerson, P. A. 2010. *Statistical Methods for Geography - A Student's Guide*. New Delhi: SAGE Publications Ltd.
- [35] Singh, R. D. 1997. *Principles and Practices of Modern Coal Mining*. New Delhi: New Age International (P) Limited.
- [36] Singh, A. K. 2006. Modern World System and Indian Proto-industrialization: Bengal 1650-1800. India: Northern Book Centre.
- [37] Sinha, S. 1988. Regional Structure, Processes, and Patterns of Development: A Case Study of the Chota Nagpur Region. India: Concept Publishing Company.
- [38] Taly, M. B. 1971. Coal and Its Rail Transport in Bengal and Bihar Coalfields. India: Research Designs and Standards Organization, Ministry of Railways.

