Environmental Impact of Coal Mining on Local Livelihoods in Odisha, India

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ABSTRACT

The study aims to examine the sustainable livelihoods framework (SLF) of local people in Talcher coal mining in Odisha. The study used five types of capital such as human, social, financial, physical and natural. The Herfindahl Hirschman index has been used to differentiate income diversification in mining villages and control villages. The backwards step-wise multiple regression model has been used to show the relationship between expenditure and different socio-economic variables in the mining villages. The Mining has a positive footprint on physical capital. But it has detrimental effects on natural and mixed effects on human, social and financial capital in the mining villages. The Herfindahl index and multiple regression models revealed that mining has a positive influence on the livelihoods of people in the mining area. There is more livelihoods diversification in the mining villages than in the control villages. The standard of living and income has increased in the mining villages. There are some challenges faced by the mining communities such as job insecurity and livelihoods insecurity for their children. The adverse impact of coal mining on livelihoods can be minimised by controlling environmental degradation through rigorous monitoring. Further, there should be proper coordination between the state government and coal mining companies to provide benefits to the affected communities and conduct different training programmes on driving, computer training and tailoring to people who not engaged in mining activities. Institutional farsightedness is required to ensure sustainable livelihoods for local people.

Key words : Coal mining, Sustainable Livelihoods framework, Livelihoods, and Herfindahl Hirschman index.

Introduction

Coal mining is a basic input for industrialisation. It brings about both winners and losers. The winners derive net benefits in boosting economic development and creating nourishment for masses. The losers endure net costs arising from environmental externalities. Coal mining provides the raw material, revenue, foreign exchange, employment and many more benefits. Coal is a non-renewable resource having finite stock on the earth's surface which is a part of the ecosystem. Coal is a necessary raw material for steel and iron production. This energy fuel is used in the production of aluminium, cement, chemicals, paper, manganese, synthetic rutile, glass and pharmaceuticals other highly energy-based industrial products. Coal is a prime fossil fuel. It is used as electricity in many countries all over the world. Coal mining in India is salient in electricity generation. It contributes about 82 percent to electricity generation and second largest producer in the world. Coal resources are accessible profusely in India. It meets 55 percent of the country's energy needs.

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Odisha is one of the Indian states richly endowed with coal resources and stood the second largest in the country in terms of coal deposits. There are two coal-bearing areas in the state, Talcher and IB valley coalfields. There is no exception to the fact that the state benefits from coal mining, but it is unable to escape the grip of its negative effects, which include loss of local ecology, biodiversity, forest loss, deterioration of water and air, loss of NTFPs, agricultural potential and loss of livelihoods of local people (Hota and Behera, 2016). Coal mining also influences the livelihoods of people. It negatively impacted the financial and natural capital and positive impact on physical and human capital (Mishra, 2009). With this background, the present study examines the impact of coal mining on the livelihoods of people in the Talcher region, Angul district, Odisha. This paper is organised into six sections. The first section is the introduction and the second is on the review of the literature. Third section speaks about study area description and sampling procedure and fourth section on model specification and estimation technique. Fifth section deals with results and discussion. Section sixth concludes the study.

Review of Literature

The following literature focuses on the impact of mining on the environment and local livelihoods in general and coal mining in particular. Paltasingh and Satapathy (2021) tried to show the negative effects of coal mining activities. It has a detrimental effect on different sources of livelihoods. Similarly, Segerstedt and Abrahamsson (2019) stated diversified livelihoods can be used as social sustainability approaches such as gender equity, migration, housing infrastructure and demographics. Mishra (2018) assessed mining closure as good for the environment but it negatively impacts on livelihoods of mining communities. Moreover, Das and Mishra (2015) showed coal mining has improved the income of local people and also helped to create diversified livelihoods in local areas.

Mishra and Das, (2017) conducted the study in MCL, Talcher coalfields in Odisha highlighted the coal mining impact on the local environment. The coal mine is providing employment opportunities and diverse livelihoods opportunities.

Hota and Behera, (2016) focussed on sustainable livelihoods and coal mining. They have analysed the impact of coal mining on sustainable livelihoods through a sustainable livelihoods approach. The study found that in the mining villages there were more diversified livelihoods opportunities than in the control villages. Most of the people in the mining villages were engaged in mining activities. Mining has a positive impact on physical, and financial capital but an adverse effect on natural, social and human capital. They have suggested that the mining operation should be carried out properly so that environmental and social conflict can be avoided. The study suggests that government interference is mandatory to check the CSR activities of the affected people.

Mwakumanya *et al.* (2016) have deliberated the socio-economic and environmental impact on women in the Kasigau mining zone, Kenya. The women were engaged in agriculture, selling gemstones, artisanal mining, business activities, basket weaving and casual labour. This livelihoods source contributed to their income, enhanced family welfare and reduced poverty. There were many challenges faced by the mining communities such as bad roads, lack of health facilities, the spread of contamination diseases, human and wildlife disturbances, lack of safety equipment, inadequate mining ventures and untrained mining workers. The situation is worsened with water pollution, air pollution, injuries to women due to mine collapse, loss of biodiversity, land degradation, loss of family values, sexual harassment, vector diseases, prostitution, the spread of HIV/AIDS and criminal activities.

Mishra (2009) highlights the negative and positive impact of coal mining on the livelihoods of local communities in IB valley coalfield, Odisha. While the author states many positive benefits i.e. creation of foreign exchange earnings, revenue generation establishment of schools, colleges, hospitals and better roads in local areas. He also highlights the negative of mining activities on society and the environment like displacement, loss of forest-based livelihoods, forests, homes, agricultural land, degradation of the environment and air and water pollution.

Dutt (2007) Mining laws relating to coal mining are meant to protect the livelihoods of local communities. Whether illegal mining is protecting the local communities or not is questionable. So we need to rethink mining law and local community development.

As expected from the literature review, there is a clear distinction between different schools of research. Although some authors made the argument that coal mining activities chalked out a path of sus-

tainable livelihoods for local communities, they qualify their conclusion by highlighting the pivotal and crucial impact on environmental pollution.

Study area description and sampling procedure

The present study was conducted in Bharatpur, Bhubaneswari and Lingaraj area of Talcher coalfield in Angul district of the Indian state of Odisha In these coalfields the mining activities are managed by Mahanadi Coalfield limited one of the subsidiaries of Coal India limited. There are 14 approved coal mining projects and eight coal mining areas in Talcher namely Jagganath, Bhubaneswari, Bharatpur, Hingula, Lingaraj, Kaniha, Subhadra and Talcher area (UG). All these coalfields cover an area of 1800 sq km (Mahanadi Coalfields Limited, 2020). We have selected the villages from the vicinity of Bharatpur, Bhubaneswari and Lingaraj. The coal exploration was started in 1837 in the area. The geological survey took exploration work in the eastern part in the late fifties and the central part during 1963-65. The northern and western parts of coalfields such as Nandira of Bharatpur and Kalinga block were explored during 1971-75 after the nationalisation of coal mines in the 1970s (Mahanadi Coalfields Limited, 2017). As the area got developed and people were more engaged in coal mining activities and their involvement in agriculture gradually decline.

Sampling procedure

The primary data are collected during the month of October 2021. We have carefully designed the questionnaire by including all relevant information. For validity and reliability, we conducted a pretesting questionnaire to design a well-structured questionnaire by asking people verbally about different problems of the study area on which the study is based. We have covered five mining villages namely Kandhal, Raghunathpur, Jamubahali, Arakhpal and Talabeda. These villages are situated 0.5-1.5 km away from the open cast coal mining. Simple random sampling has been adopted to collect data from these villages. The control villages are Luhundi, Gurujang and Telibahal. These villages are 12-14 km away from the mining area. We have gathered information from these villages on livelihoods, income and household expenditure. We have taken care of the social composition, distance and livelihoods of households. Finally, our survey covered 200 households from mining villages and 100 households

from control villages. The following formula for sample selection has been used. Coal mining was started more than a century ago. It is difficult to go back before and after comparison. Therefore we have adopted with and without approach.

Model specification and estimation technique

The study has been used the regression model to show the relationship between expenditure and different socio-economic variables. The following general linear regression model consisting of k variables has been used to show the relationship between the monthly expenditure and no. of predictor variables like age, income, education, working hours, family size, work day lost, health cost, averting cost and family size in the mining villages.

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} \ldots\ldots\ldots\ldots\ldots\ldots + \beta_K X_{ki} + u_i \qquad .. (1)$$

Where Y_i is the monthly expenditure and $X_{1i}....X_{ki}$ is set socio-economic characteristics. Here β_0 is the intercept, β_1 to β_K are partial slope coefficients, u is the stochastic disturbance term and i represent observation or households (Shyamala, Kaur and Pragasm, 2016).

The Herfindahl Hirschman index has been used to show income diversification in the mining villages and control villages. The following Herfindahl Hirschman index (HHI) and diversification index are expressed as.

$$\text{Herfindahl Index (H)} = \Sigma S_i^2 \qquad .. (2)$$

Where $S_i = y_i/Y$, y_i is the income of the ith respondents and Y is the total income of all respondents (Barthwal, 2010)

The diversification index can be obtained by subtracting the Herfindahl index from 1.

$$D = 1 - H \qquad ...(3)$$

HHI is calculated by taking the square of income share to the total income of the village. In the second step, we summed the obtained number.

Results and Discussion

Sustainable Livelihoods Framework (SLF)

The concept of a sustainable Livelihoods framework is the cornerstone of different Livelihoods approaches. This concept has been accepted by British Department for International Development (DFID). The DFID has developed a sustainable livelihoods framework which is widely accepted in develop-

ment practice. In 1997, the SLF was merged into its programme. DFID has accepted Chambers Conway's definition of SLF "A livelihoods comprises the capabilities, assets and activities required for a means of living. A livelihoods is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (DFID, 1999). The sustainable livelihoods framework can be applied to the specific local setting. The SLF can be achieved by managing the vulnerability, livelihoods assets, livelihoods strategies and livelihoods outcomes. A sustainable livelihoods framework (SLF) means households make a living by using five types of capital or resources (natural, physical, human, social and financial) in a society impacted by organised and structural factors. Coal mining activities influence the livelihoods of local people in the mining villages.

In the study area, the vulnerability to people is in the form of exposure to air pollution and different environmental degradation due to coal mining activities. This shock deteriorates their health condition and negatively impacts different assets which affect the livelihoods outcome. They have a range of assets through which they can achieve the livelihoods outcome. Furthermore, they adopt different strategies like mitigating and averting behaviour and engaged in different activities to achieve their livelihoods goal. These livelihoods will be sustainable in the study area when they manage and recover from shock and risk. Sustainable livelihoods can be possible with environmental sustainability, economic sustainability and social sustainability. Therefore study tries to analyse the livelihoods of local people in a sustainable framework by using five types of capital.

Economic and Livelihoods activities of households

The livelihoods outcome in the study area depends on different activities in which people are engaging and different facilities in which they are availing themselves. The key features of sample villages includes different facilities, services, communication and activities. All mining villages are closer to open cast mining ranging from 0.5 km to 1.5 km and control villages situated away from mining areas ranging from 11 km to 14 km. All the sample villages are within the Talcher block. In all the sample villages the social composition is mixed. The majority of people in mining villages are engaged in mining

(29.5%) and wage labour (41.5%) for their livelihoods. Some respondents also hinge on their business, agriculture, dairy, security guard, rope weaving, driver, kabadiwala, private school job and salaried income. All sample villages have both primary and upper primary schools in Kandhal, Talabeda and Gurujang. Talabeda and Gurujang have secondary schools. All villages have an electricity connection. The people of sample villages rely on tubes well and well. MCL is also providing water in a few villages but not regularly. Gurujang has 832 households with a 3478 population which is the highest and Talabeda village has 14 households with 60 population which is the minimum in all sample villages (see Appendix-A).

People engaged in different economic activities for their livelihoods. People engaged in diverse economic activities can enhance their income. Table 1 shows the economic activities of sample households. In the mining villages, households rely upon agriculture, business, dairy, wage labour, mining and others. In the mining villages, most of the people are engaged in wage labour. The age share is 41.5 percent in wage labour followed by 29.5%, 19.5%, 8%, 1% and 0.5% in mining, other, business, agriculture and dairy/livestock respectively. Similarly, in the control villages, households confide in agriculture, business, dairy and wage labour.

Table 1. Economic activities

Economic activities	Mining villages	Control villages
Agriculture	2(1)	6(6)
Business	16(8)	18(18)
Dairy	1(.5)	1(1)
Wage Labour	83(41.5)	18(18)
Mining	59(29.5)	22(22)
Other	39(19.5)	35(35)
Total	200(100)	100

Source: Field study, 2021
Notes: Figures in brackets show the percentage of total

The highest number of households engaged in the miscellaneous category and their percentage share is 44 percent followed by wage labour (30%), business (18%), agriculture (7%) and dairy/livestock (1%).

Human capital

In the livelihoods framework, human capital consists of skills, knowledge, ability to work and good

Appendix-A

Key Features of Sample Villages

Features	Mining Villages					Control Villages		
	Kandhal	Raghunathpur	Jamubahali	Arakhpal	Talabeda	Luhundi	Gurujang	Telibahal
Distance from nearby mines	1.5km	1km	1km	0.5km	0.5km	11	12	14
Total Population	1117	650	1212	555	578	279	3478	60
Social composition	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed
Total Households	248	121	243	115	127	56	832	14
Livelihoods	Mining jobs, businesses, marginal workers	Mining jobs, marginal workers	Mining job, business, Wage labour	Wage labour marginal workers, Mining job	Main workers, Business, Mining job	Wage labour, Main workers	marginal workers, Wage labour, Cultivator	marginal workers, Wage labour
Electricity	Available	Available	Available	Available	Available	Available	Available	Available
Drinking water	Tube well, MCL water	Well, tube well	Tube well, well	Well, Tube well	Tube well, well	Tube well, well	Tube well, well	Tube well
Infrastructure	Primary & upper primary school	Primary school	Primary school	Primary school	Primary & Upper Primary school, secondary school	-	Primary & Upper Primary school, secondary school	-

Source: Census data, 2011 and Field Survey, 2021

health conditions that together entitle people to pursue various livelihoods strategies and fulfil their objectives. Table 2 depicted the educational status of sample households. The illiteracy rate is diminutive in the mining villages (3.7). Most of the people in the mining area are educated. But the illiteracy is more in control villages in comparison to mining villages. It is 14.4 percent.

Table 2. Education status in sample villages

Education level	Mining Villages	Control villages
Illiterate	32(3.7)	61(14.4)
Up to 5	295(34.5)	156(36.9)
(6-10)	333(38.9)	159(37.6)
(11, 12)	96(11.20	31(7.3)
Technical	47(5.5)	9(2.1)
Degree	43(5)	7(1.7)
Other	10(1.2)	0
Total	856 (100)	423(100)

Source: Field study, 2021
Notes: Figures in brackets show the percentage of total

Table 3 represents the type of diseases in the mining villages. The respondents in the mining villages suffered from respiratory illness (asthma, cold, cough, and fever), malaria, skin and arthritis. RI-related diseases are more in the mining villages followed by skin and arthritis. The respondents of

Table 3. Type of illness in the mining villages

Mining	Villages Respiratory Illness (RI)	Skin	Malaria	Arthritis
Kandhal	28(26.9)	30(21.9)	22(24.2)	27(27.3)
Raghunathpur	31(29.8)	31(22.6)	27(29.7)	32(32.3)
Jamubahali	21(20.2)	24(17.5)	18(19.8)	17(17.2)
Arakhpal	19(18.3)	23(16.8)	18(19.8)	19(19.2)
Talabeda	5(4.8)	29(21.2)	6(6.6)	4(4)
Total	104(100)	137(100)	91(100)	99(100)

Source: Field study, 2021
Notes: Figures in brackets show the percentage of total

Raghunathpur suffered more from RI-related diseases (22.6%), skin (29.8%), malaria (29.7%) and arthritis (32.3 %). In course of frequent interaction with respondents, it came to notice that some villagers suffer from blood pressure (BP), cancer and heart problems. However, it is recorded that in the mining villages, these ailments are fewer. There is no incidence of cancer and heart problem in Kandhal, Raghunathpur and Jamubahali. But Arakhpal and Talabeda have witnessed the spurt of these diseases. Respondents were unable to attend their work due to illnesses caused by mining activities. There is no such measure of health problem traced in the control villages. Mining has a mixed impact on human capital.

Social Capital

Social capital is the social resources or capital upon which people fulfil their livelihoods objectives in an SLF. These resources or capitals are developed through connectedness and networks that increase people's trust and ability to work together and expand their access to wider institutions, such as political or civic bodies.

The people's connectedness increased after the mining exploration. Mining has provided jobs and rehabilitation packages to the people. At the same time, they got displaced from their land. They have lost their agricultural land and forest-based livelihoods. We have discussed with the people of two rehabilitated villages namely Biraramchandrapur and Kalamchuin did not leave their villages because they did not receive the proper rehabilitation package. These villages were already rehabilitated by the government and MCL. Some of the mining villages like Kandhal, Raghunathpur and Talabeda express their willingness to resettle in some other place away from the mining zone because they are coming under the active mining zone. They also complain that their nearby villagers have already been rehabilitated and got compensation amount with mining jobs. They also want to get the facilities which were already availed by people of nearby villages because they face a lot of environmental problems. For these reasons, they fight together for the common cause of their respective villages.

In the mining areas, members are getting facilities of the public distribution system, Sarva Shikha Abhiyan (SSA), Mo kudia yojana, old age pension and primary health care. Most of the households

trust each other in their respective villages in the mining area. The trust rate is ranging from 78 to 92 percent. Some households are very careful in dealing with the villagers. Most of the people in Jamubahali do not trust lending and borrowing. In the matter of lending and borrowing, they deal carefully. In the Raghunathpur village, 75 percent of people trust which is the highest. In Jamubahali and Talabeda 70 percent of people do not trust in the matter of lending and borrowing. Similarly, in control villages, most of the people trust each other in their respective villages. It varies from 87 percent to 98 percent and does not trust varies from 2 percent to 13 percent. The trust in lending and borrowing varies from 75 to 85 percent and not trust varies from 15 to 25 percent (Table 4). Peoples in the mining villages report job availability by a private agency. The private agency also employs people from other districts. Sometimes, this creates job insecurity among people. Mining has both negative and positive impacts on social capital. No such problem was found in the control villages.

Natural Capital

Natural capital means natural resource stocks from which resource flows and services (nutrient cycling and erosion protection) are useful for deriving livelihoods. It is very important for poor people as they sustain their livelihoods from natural resource-based activities (farming, fishing, gathering in forests, mineral extraction, etc.). The natural capital in the study villages consists of agricultural land, water resources and environmental quality.

The land holding status is displayed in Table 5. Sixty-five percent of households have land in

Table 4. Lending and borrowing trust of sample villagers

Study Areas	Trust		Trust in the activities of lending and borrowing	
	Village people can be trusted	Careful in dealing with village people	Do trust	Do not trust
Mining villages				
Kandhal	90%	10%	70%	30%
Raghunathpur	92%	8%	75%	25%
Jamubahali	78%	22%	30%	70%
Arakhpal	91%	9%	40%	60%
Talabeda	85%	15%	30%	70%
Control Villages				
Luhundi	87%	13%	80%	20%
Gurujang	92%	8%	75%	25%
Telibahal	98%	2%	85%	15%

Source: Field survey, 2021

Kandhal village which is the highest among all sample mining villages. In control villages, all households have no land. Gurujang has the highest agricultural land and the lowest number of agricultural lands is in Luhundi. Their percentages are 46.7 and 13.33 respectively.

Table 5. Status of land and NTFP collection

Study Areas	HHs having Agricultural Land	HHs Collecting NTFP
Mining villages		
Kandhal	65%	Nil
Raghunathpur	30%	Nil
Jamubahali	20%	Nil
Arakhpal	10%	Nil
Talabeda	40%	Nil
Control Villages		
Luhundi	13.33%	Nil
Gurujang	46.7%	Nil
Telibahal	40%	Nil

Source: Field survey, 2021
Notes: Figures in brackets show the percentage of total

In all sample villages, the households do not engage in NTFP collection. In the mining area, the mining activities negatively impact forest, water, air and biodiversity. In the control villages, there is no degradation of water, air and environment. There is no forest near the control villages. The sample villages depend on wells and tube well for drinking water (Table 6). The respondent reported that the quality of water in ponds and open wells got deteriorated due to coal dust in the mining area. They suffered water scarcity during summer. The MCL did not supply the water regularly in the mining villages. They also suffered from air pollution. But no such pollution was found in the control villages.

Physical Capital

Physical capital comprises the basic infrastructure

Table 6. Sources of drinking water in mining villages

Sources	Drinking	Bathing
Tube well	73(36.5)	72(36)
Well	114(57)	99(49.5)
Pond	0	29(14.5)
MCL water	13(6.5)	0
Total	200(100)	200(100)

Source: Field study, 2021
Notes: Figures in brackets show the percentage of total

and producer goods required to maintain livelihoods. The infrastructure consists of changes to the physical environment that help people to meet their basic needs and to be more productive. All these include secure shelter; affordable transport; buildings; adequate water supply and sanitation; clean, affordable energy; and access to information and communications. All sample households have their own houses. Most of the households in the mining villages are staying in semi-pucca houses followed by pucca and Kucha houses. In the control villages, 62 percent are staying in semi- pucca houses and 29 percent and 9 percent are staying in the pucca and kutcha houses respectively (Table 7). The physical assets such as cycles, motorbikes, four-wheelers, television and mobile are possessed by all sample villagers (Table 8). The percentage of some physical assets like cycle (20.9%) and motorbikes (26%) are more in the control villages. Other assets like four-wheelers (1.3%), TV (20.7%) and mobile (38%) are more in terms of percentage and numbers. These differences may be due to the differences in purchasing power in mining villages and control villages. It is interesting to note that the agricultural assets are only found in the control villages. Mining has a positive impact on the physical assets in mining villages.

Financial Capital

Financial capital comprises the financial resources

Table 7. Type of houses in sample villages

Type of house	Mining Villages	Control Villages
Kutcha	17(8.5)	9(9)
Semi-Pucca	115(57.5)	62(62)
Pucca	68(34)	29(29)
Total	200(100)	100

Source: Field survey, 2021
Notes: Figures in brackets show the percentage of total

Table 8. Physical assets

Physical assets	Mining villages	Control villages
Cycle	124(17.3)	70(20.9)
Motorbike	163(22.8)	87(26)
Fourwheeler	9(1.3)	1(.3)
TV	148(20.7)	61(18.2)
Mobile	272(38.0)	116(34.6)
Total	716(100)	335(100)

Source: Field study, 2021
Notes: Figures in brackets show the percentage of total

Table 9. Mean household income of sample villages

HH member	Mean HHs Income	Mean Per-capita Income	Mean HH size (No)
Mining Villages	Rs. 15,550	Rs. 3,643.72	4.335
Control Villages	Rs. 11,082	Rs. 2,243.19	4.26
T-statistics	5.312*	1.68**	9.017*

Source: Field study, 2021
*Significant at 1 percent, **significant at 10 percent

Table 10. Ownership Distribution by Households of Selected Livestock

Livestock	Mining villages	Control villages
Cow	327(95.89)	113(83.7)
Goat	14(4.1)	15(11.11)
Hen		5(3.7)
Total	341(100)	135(100)

Source: Field survey, 2021
Notes: Figures in brackets show the percentage of total

that people use to fulfil their livelihoods objectives. It is required to capture a prime livelihoods building block, namely the availability of cash or equivalent that enables people to adopt different livelihoods strategies. Table 9 reflects about financial capital of sample households. We have taken here household mean income for this purpose.

The mean income of mining villages is Rs.15,550 and the mean income of control villages is Rs.11,082. In the mining village, the mean per capita income is Rs. 3643.72 and the mean per capita income in control villages is Rs.2243.19. It is interesting to notice that there are not many differences in mean household size in mining and control villages. It is 4.33 and 4.24 respectively. Mean household income and mean household size is significant at 1 percent and mean per capita income is significant at 10 percent.

Table 10 unfolds the livestock holding by sample villages. In the sample villages, the major livestock is cow, goat and hen. All mining villages have cows

Table 11. Results of Herfindahl Hirschman Index and diversification index

HH member	HHI	Herfindahl Diversification index
Mining Villages	0.008	0.991964
Control Villages	0.0335	0.966496
T-statistics		3.062*

Source: Computed
*Significant at 1 percent

but goats are available in Kandhal village only. Arakhpal has 27.7 percent cows which is the highest among mining villages. The lowest cows are in Kandhal(4.5%). Similarly, two villages have livestock in control villages. The maximum number of cows and goats are found in Gurujang and hens are found only in Luhundi. The livestock population are decreasing in the mining villages because of polluted water and grazing land. There is no such problem in the control villages. The villages of the mining area suffered a loss in income from livestock and agriculture. Therefore mining has a mixed effect on financial capital.

The source of income varies in mining and control villages. There are more sources of income available in the mining villages than in the control villages. The sources of livelihoods in the mining villages are agriculture, dairy, business, wage labour, mining and others including mechanics, salaried person, tailoring etc. Livelihoods sources in the control villages are business, agriculture, wage labour, dairy and others. Herfindahl index shows income diversification in both villages.

Table 11 depicts the results of HHI. We have obtained the coefficient of HHI which is 0.008 for mining villages and 0.0335 for control villages. The diversification index is obtained by subtracting the HHI from 1. The diversification index is 0.99 in mining villages and the diversification index is 0.96 in control villages. The value of the diversification index is more in mining villages than in control villages. That means there are more sources of livelihoods available in mining villages and fewer livelihoods are available in the control villages. People of mining villages are in a more advantageous position than in control villages. Herfindahl's diversification index is significant at 1 percent.

The Multiple regression

This section estimates the relationship between monthly household expenditure and different socioeconomic variables in mining villages by employing

backwards step-wise regression using the ordinary least square method in STATA 12.0. The advantage of the backwards stepwise regression is that gives a better model. In the backwards step-wise regression generally, we omit or add one variable in each step to get a better model. Table 12 represents the name and definition of the variables.

In backwards step-wise regression we finally regress REINCM, REWHNM, RESWDL, RESAAC, RESFEM and RESFSZ on HHEXPM. We have taken only significant independent variables. The variables like REINCM and REWHNM are significant at 1 percent, RESWDL, RESAAC, RESFEM and RESFSZ are significant at 5 percent. The explanatory power of the model is found to be significant with a high value of adjusted R^2 at 0.79. The R^2 value of 0.79 means about 79 of the variation in monthly household expenditure is explained by the variation in the six explanatory variables. The output shows that the monthly expenditure is statistically significant with six predicted variables, $F_{(6, 191)} = 99.51$, $p < .0005$. This indicates the goodness of fit. The estimated regression model (best-fitted regression equation) is presented in Table 13. The best-fit regression equation is expressed below.

$$\widehat{HHEXPM} = 5500.3 + .31REINCM - 1561.8REWHNM + 1290.6RESWDL +$$
$$\quad (4.93) \quad (15.29) \quad (-3.52) \quad (2.69)$$

$$2.8RESAAC + 879.32RESFEM + 289.6RESFSZ \qquad\qquad .. (4)$$
$$\quad (2.03) \quad (2.41) \quad (1.95)$$

Table 12. Name and Definition of the variables

Variable name	Explanation (**Dependent variable**)	Units of measurement
HHEXPM	Household expenditure of Respondents of Mining village	Rs.
HHEXPC	Household expenditure of respondents of Control village	Rs.
	Independent Variable	
RESAGE	Respondents age	No. of Years
REINCM	Respondents income	Rs.
RESPCI	Respondents' Per capita income	Rs.
RESWHM	Respondents Working hours in mining	No. of hours per day
REWHNM	Respondents Working hours in non-mining	No. of hours per day
RESHCT	Respondents health cost	Rs.
RESWDL	Respondents' work day lost	Days
RESAAC	Respondents' average averting cost	Rs.
RESEDU	Respondents Education	No. of Year
RESFEM	Earning member of the respondent's family	Number
RESFSZ	Respondents Family size	Number

Source: Computed

Table 13. Multiple regression

Independent variable	Coefficient	P-value	Standard error
RESAGE			
RESINCM	.307(15.29)*	0.000	.0194939
RESWHM			
RESWHNM	-1561.8(-3.52)*	0.005	441.0003
RESHCT			
RESWDL	1290.6(2.69)**	0.024	140.3275
RESAAC	2.78(2.03)**	0.034	5.374733
RESEDU	—	—	—
RESFEM	879.32(2.41)**	0.039	378.3397
RESFSZE	289.6(1.95)**	0.009	153.9416
Constant	5500.25(4.93)	0.000	914.5058
R Square	0.79		
Adjusted R Square	0.78		
Prob>F	0.0000		

Source: Computed

Conclusion

In the educational attainment in the mining villages, more people have studied above +2 than in control villages. Similarly, in control villages, more people have agricultural land than in mining villages. In sample villages, people are engaged in different types of economic activities such as mining, business, wage labour, agriculture, dairy/livestock, driver, salaried income, tailoring, security guard and mechanics. The average income in the mining villages is more than in the control villages. The earning members other than respondents are more in the mining villages than in control villages. Moreover, both villages have different physical assets. But agricultural assets are only found in controlled villages. The control villages spent less on other items than the mining villages. The farming activities are more in the control villages than in the mining villages. Mining has a positive footprint on physical capital. But it has detrimental effects on natural and mixed effects on human, social and financial capital in the mining villages. Sometimes mining villagers face job insecurity compared to outsiders. The rate of coal exploitation and environmental degradation create challenges for the livelihoods of their children. The Herfindahl index and multiple regression models used in this paper reveal that mining has a positive influence on the livelihoods of people in the mining area. Their income and standard of living have increased due to coal mining. There is also more livelihoods diversification in the mining villages than in the control villages. Therefore the environmental control measures need to be more rigorous to control the different environmental problems to restrain the detrimental effects of mining on different livelihoods assets. Further, there should be proper coordination between the state government and coal mining companies to provide benefits to the affected communities and conduct different training programmes on driving, computer training and tailoring to people who not engaged in mining activities. Institutional farsightedness is required to ensure sustainable livelihoods for local people.

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Conflict of interest

There is no conflict of interest among authors.

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