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# Induced Pollution and Sustainable Development of Coal Mining in Odisha, India

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**ABSTRACT**

*Over the past two decades there has been growing importance of sustainable development principles within the mining sector. Coal mining is the foundation of India as well as Odisha's economic development. It provides energy safety. However, continued production of minerals and fossil energy fuels may not fit into sustainability principle. A number of coal mining companies, all over the world, have embraced sustainability as a prime aspect of corporate philosophy. The increasing need of sustainable mining has been realised especially in the light of environmental externalities and global warming. It is in this context, the research problem has been built. Mahanadi coal fields limited (MCL) which was carved out of south eastern coal field limited (SECL) was formed on 3rd April 1992 with its head quarters at Sambalpur, Odisha. The coal reserve of MCL is spread over its two coal fields viz Talcher and and IB River valley with ten operating areas consisting six underground and sixteen open cast projects under its fold. To what extent MCL seems to take care of the environmental externalities? Does it adopt the sustainable mining operations? These are some of the queries which the paper attempts to ponder.*

*The study is based on secondary data which is mostly collected from websites, annual reports and sustainability reports of MCL. A number of documents and literature are to be accessed through internets. This paper is organised into varied sections. Followed by this introduction, the second and third section are on review of literature, concepts and meaning of sustainable coal mining operation. Section four describes about profile of MCL. Section five and six analyse the data. The sustainable coal mining is delineated in the subsequent section. The paper ends with brief concluding remarks.*

*Keywords: Sustainable Development, Coal Mining, Sustainability, Environmental pollution*

## 1. INTRODUCTION

The concept of sustainable development within the mining sector has accepted over past two decades. This concept in coal mining is now not new, has become active in sustainability effort. Now various global coal mining companies belief sustainability as key aspect of corporate philosophy. Coal plays an important role in sustainable future as the most widely used energy source in electricity generation and steel production globally. Coal mining in India is also play an important role in electricity generation. It contributes about 82% of electricity generation and was top third coal producer in the world. Coal mining provides raw materials for industrial development and creates job opportunities for local people. Further, it has spill-over benefits like schooling, hospitals, and transport and communication facilities in the mining areas. However the rising demand would result in increased coal mining and consequently the concern over the ecological degradation, biodiversity losses, air, water, noise pollution and adverse activities on agricultural production (Mishra and Pujari 2008). Coal mining creates employment, generates value, and improves the foreign investment of a country or region. However, it has its disadvantages including negative externalities. The coal mining activities in area like uncovered coal transportation, lack of water spraying system and movement of heavy vehicles, brought to air pollution to the locality suspended particulate matter concentration is alarmingly high in local area. The extraction of mining has influenced the water table (Mishra and Das, 2017). Health externalities of social cost of coal has increasing it causes respiratory health problem. Health externality effects of coal power plants in India (Guptaa and Spearsb, 2017). Health problem due to coal mining are fevers, gastritis, skin diseases, joint pain and, also cases of weakness, cough and cold, asthma and gynaecological problems. Due coal mining activities it causes water pollution, water pond are filled coal dust, also causes air pollution with coal loaded trucks (Mishra, 2009).

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The sustainable development presents a considerable challenge to the coal mining in India. To meet the increased demand of coal, it threats to the environment. In this context, the research problem has been built.

Sustainable development of coal mining in Odisha is one of the Indian state is also a challenge because it causes air, water, noise pollution, ecological degradation, biodiversity loss and also it causes damage to human health. Therefore present study analyse the economic and environmental sustainability of coal mining in Odisha. To what extent coal mining companies (public and private) seems to take care of the environmental externalities? Does they adopt the sustainable mining operations? These are some of the queries which the paper attempts to ponder.

**1.1 REVIEW OF LITERATURE**

The sustainable development concept in coal mining is now not new, has become active in sustainability effort. Now various global coal mining companies belief sustainability as key aspect of corporate philosophy. The literature reviewed here are showed how coal mining impact on economy, society and environment.

Coal mining creates employment, generates value, and improves the foreign investment of a country or region. However, it has its disadvantages including negative externalities. The coal mining activities like uncovered coal transportation, lack of water spraying system and movement of heavy vehicles, brought to air pollution to the locality suspended particulate matter concentration is alarmingly high in few sampling locations. The extraction of mining has influenced the water table (Mishra and Das, 2017). Health externalities of social cost of coal has increasing it causes respiratory health problem. Health externality effects of coal power plants in India (Guptaa and Spearsb, 2017). Health problem due to coal mining are fevers, gastritis, skin diseases, joint pain and, also cases of weakness, cough and cold, asthma and gynaecological problems. Due coal mining activities it causes water pollution, water pond are filled coal dust, also causes air pollution with coal loaded trucks (Mishra, 2009). It has been observed that coal mining impact on the economy, society and environment in local areas. Although mining activities bring about economic development in the area, it also causes land degradation that creates ecological and socio-economic problems (Goswami, 2015).

In most of the developing countries energy requirements are met from coal-based thermal power plants. The disposal of solid waste from coal-based thermal power plants is causing environmental degradation. In developed countries like Germany, 80% of the fly ash generated is being utilized, whereas in India only 3% is being consumed (Senapati, 2011*)*. To overcome from environmental problem proper management is required by Govt (Goswami, 2015). The policy-maker needs to consider measures to reduce the level of coal exploitation to save the environment. To reduce coal based thermal plant pollution government should impose tax and benefits must be transfer to local people (Fatah, 2008). Fly ash becomes an important raw material for various industrial and construction applications. Fly ash is widely used in construction of bricks, cement, asbestos-cement products, and road/embankments. Fly ash is being studied for improvement of agricultural crops, wetlands and zealites. Fly ash has found application in domestic and wastewater treatment and purification and paint and enamel manufacturing (Dhadse, Kumari and Bhagia, 2008). So, the disposable management of fly ash from thermal power plant is necessary to protect our environment (Avimeni and Bandlamudi, 2013). Coal based thermal plants produced waste fly-ash or coal ash which cause environmental pollution (Haque, 2013).

The coal mining improves economic condition of adjacent community, and they displaced from their land, it also causes environmental degradation. For sustainable development coal mining care should be taken to minimise environmental damage.

**1.2 OBJECTIVES OF THE STUDY**

The following are the objective of the study.

1) To examine economic benefit of coal Mining in Odisha

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2) To investigate the induced pollution and sustainable development of coal mining in Odisha.

**1.3 METHODOLOGY**

The study is based on secondary data collected from Indian Bureau Of mines, government of India, Directorate of Mines, government of Odisha, Ministry of coal, government of India, Ministry of Environment, Forest and Climate Change, GOI, Annual reports of CIL, MCL, Economic survey of Odisha and state environment report of Odisha. The data are analysed through SPSS, descriptive statistics, simple linear regression and Compound Annual Growth rate (CAGR) are used to analyse the data.

In this paper, simple linear regression model is used to analyse the relationship between fly ash utilisation and fly ash generation.

The simple regression model is

$$\mathbf{Y_{it} = \beta_0 + \beta_1 X_{it} + U_{it}}$$

Where $Y_{it}$ is a dependent variable is explain fly ash utilisation and fly ash generation is independent variable for sample observation i at time period t. Whereas $\beta_0$ is constant, $\beta_1$ is slope and $U_{it}$ is the error term. The fly ash utilisation and fly ash generation data are used from 2010-11 to 2017-18.

The paper divided in to three sections, first section deals with introduction, review of literature, objective of the study and methodology. The section-II explain sustainable coal mining concept. The third section investigates economic benefit of coal mining in Odisha. Section-IV analyse induced pollution and sustainable development of coal mining in Odisha and section-v concludes the study.

**2. SUSTAINABLE COAL MINING**

This section examines the sustainable development (SD) and mining under varied concepts of sustainability. The World commission on the Environment and Development defined SD as development that meets the needs of the present without compromising the ability of future generation to meet their own needs (WCED 1987). The neoclassical growth theory (Hartwick 1977) which incorporated natural resource constraints on economic activities modelled SD as non declining consumption over time. They were concerned with intergeneration efficiency rather than equity. Hanley et.al, (1997).

Hartwick proposed non-declining consumption through time as the rule for SD (Hanly et.al. 1997). Basing on the contribution of the London school of Environmental Economics (Khassen & Opschoor 1991, Pearce and Turner, 1990) formulated the rule focussing on the limited degree of sustainability between natural capital and human made capital. It is recognised that natural resources have an essential and implacable economic role to play (Daly 1991). Closely linked to the non declining natural capital stock approach is the safe minimum standards approach (SMS) of Ciciry-wantrup (1952). The rule is to prevent reductions in the natural capital stock below a safe minimum standard identified for each component of this stock. Daly (1990) provides certain operational rules which would be helpful for nations to move on SD path. In case of renewable resources the rule is to set all harvest levels at less than or equal to the population growth rate for some predetermined population size. For degradable pollutants, establish assimilative capacities for ecosystems. In case of non renewable resources like coal mining the depletion should be compensated by creation of renewable resources through investments in natural capital.

Sustainability is thus fundamentally reconciliation between development and the environmental resources on which society depends. In other words it is a choice between the weak sustainability (WS) and strong sustainability. Under the regime of WS natural capital is allowed to be degraded or depleted, but it must be offset by equal or greater increases in other forms of capital. Strong sustainability requires for separate maintenance of manmade and natural capital.

As discussed above strong sustainability cannot be applicable in coal mining since it involves extraction of non renewable resources. But once it leads to non declining long term benefits it can be said as sustainable. In this paper, attempt has been to trace out whether the benefits from coal mining in terms of job opportunities for people in local region, revenue recycling an infrastructure base can flow in the long term. Is it sustainable?

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**3. ECONOMIC BENEFITS OF COAL MINING IN ODISHA.**

The economic benefits from coal mining can be analysed through coal production, value of coal, employment generation and revenue to the government. There are two major coal bearing areas in the state- Talcher and Ib valley. Angul (12 mining leases, 9,590 Ha of mining area) is the prime coal mining district followed by Jharsuguda (14 mining leases, 7,656,55 Ha of mining area), Sambalpur (1 mining lease, 170.305 Ha of mining area) and Sundargarh (1 mining lease occupying 140.84 Ha of mining area. Total reserve of coal in the 2016-17 is 75895.67 million tonnes. According coal directory, GOI, coal is produced by private and public companies. Total public coal mines are 26 and 01 private coal mines in 2007-08. From 2007-08 to 2016-17 there is only one private coal mine and public coal mines are varies from 25 to 29. The public coal mines are controlled by MCL one of the subsidiaries of CIL and private coal mines controlled by HIL (Table 1 and 2).

**TABLE-1: NO. OF COAL MINES CAPTIVE, NON-CAPTIVE, PUBLIC AND PRIVATE**

| Year | Captive | Non Captive | Total | Public | Private | Total |
|---|---|---|---|---|---|---|
| **2007-08** | 01 | 26 | **27** | 26 | 01 | **27** |
| **2008-09** | 01 | 24 | **25** | 24 | 01 | **25** |
| **2009-10** | 01 | 25 | **26** | 25 | 01 | **26** |
| **2010-11** | 01 | 27 | **28** | 27 | 01 | **28** |
| **2011-12** | 01 | 27 | **28** | 27 | 01 | **28** |
| **2012-13** | 01 | 27 | **28** | 27 | 01 | **28** |
| **2013-14** | 01 | 26 | **27** | 26 | 01 | **27** |
| **2014-15** | 01 | 26 | **27** | 26 | 01 | **27** |
| **2015-16** | 01 | 28 | **29** | 28 | 01 | **29** |
| **2016-17** | 01 | 28 | **29** | 28 | 01 | **29** |

Source: Coal Directory, Government of India

**TABLE-2: COMPANYWISE PRODUCTION OF RAW (Million Tonnes)**

| Year | MCL | HIL | TOAL |
|---|---|---|---|
| 2005-06 | 69.604 | 0.936 | 70.540 |
| 2006-07 | 80.001 | 1.159 | 81.160 |
| 2007-08 | 88.012 | 1.470 | 89.482 |
| 2008-09 | 96.336 | 2.066 | 98.402 |
| 2009-10 | 104.079 | 2.330 | 106.409 |
| 2010-11 | 100.280 | 2.285 | 102.565 |
| 2011-12 | 103.119 | 2.357 | 105.476 |
| 2012-13 | 107.895 | 2.237 | 110.132 |
| 2013-14 | 110.439 | 2.478 | 112.917 |
| 2014-15 | 121.379 | 2.248 | 123.627 |
| 2015-16 | 137.901 | 0.560 | 138.461 |
| 2016-17 | 139.208 | 0.151 | 139.359 |

Source: Coal Directory, Government of India

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**TABLE-3: PRODUCTION OF COAL, VALUE, EMPLOYMENT, SHARE, GROWTH IN ODISHA.**

| Year | Production (Million Tonnes) | Value (Million) | Employment | Production (All India)MT | Value (All India) Million | Share (All India) | Growth |
|---|---|---|---|---|---|---|---|
| **2003-04** | 60.147 | 24835.6 | 17318 | 361.246 | 258908.8 | 16.6 | -- |
| **2004-05** | 66.604 | 29012.6 | 17624 | 382.615 | 304335.1 | 17.4 | 10.7 |
| **2005-06** | 70.540 | 29748.7 | 14500 | 407.039 | 336752.6 | 17.3 | 5.9 |
| **2006-07** | 81.160 | 33437.8 | 13985 | 430.832 | 348367.9 | 18.8 | 15.1 |
| **2007-08** | 89.482 | 42115.5 | 12747 | 457.082 | 384637.1 | 19.6 | 10.3 |
| **2008-09** | 98.402 | 51725.7 | 13467 | 492.757 | 455370.1 | 20.0 | 10.0 |
| **2009-10** | 106.409 | 58751.3 | 13875 | 532.042 | 513182.5 | 20.0 | 8.1 |
| **2010-11** | 102.565 | 73545.3 | 15389 | 532.694 | 620210.4 | 19.3 | -3.6 |
| **2011-12** | 105.476 | 96399.0 | 16330 | 539.950 | 701719.1 | 19.53 | 2.84 |
| **2012-13** | 110.132 | 47256.8 | 14320 | 556.402 | 747186.6 | 19.8 | 4.4 |
| **2013-14** | 112.917 | 150160.6 | 19700 | 565.765 | 825347.5 | 20.0 | 2.5 |
| **2014-15** | 123.627 | 158984.334 | 19700 | 609.179 | 892871.7 | 20.3 | 9.5 |
| **2015-16** | 138.461 | 121010.1 | 19800 | 639.230 | 883822.1 | 21.7 | 12.0 |
| **2016-17** | 139.359 | 103882.9 | 20800 | 657.868 | 765511.5 | 21.2 | 0.6 |
| **CAGR** | **17.82** | | | | | | |

Source: Directorate of Mines, GOO, Coal Directory, GOI

**TABLE-4: DESCRIPTIVE STATISTICS**

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | **N** | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** |
| Production | 14 | 60.15 | 139.36 | 100.3772 | 24.76248 |
| Value | 14 | 24835.60 | 158984.33 | 72919.0167 | 45671.26282 |
| Employment | 14 | 12747.00 | 20800.00 | 16396.7857 | 2747.85125 |
| ProductionIndia | 14 | 361.25 | 657.87 | 511.7644 | 93.57837 |
| ValueIndia | 14 | 258908.80 | 892871.70 | 574158.7857 | 228505.15151 |
| Share | 14 | 16.60 | 21.70 | 19.3950 | 1.44798 |
| Growth | 14 | -3.60 | 15.20 | 7.3957 | 5.51601 |
| Valid N (listwise) | 14 | | | | |

The economic benefit from coal mining is explained with the help of table 3 and table 4. It shows coal production in Odisha, value of coal, employment, its growth. Highest coal production was 139.359 million tonnes in 2016-17. And lowest coal production was 60.14 7 million tonnes in 2003-04. The value of coal was Rs. 24835.60 million in 2007-08. The highest coal value was Rs. 158984.33 million in 2014-15. The coal mining in Odisha also provides employment to 12747 nos. of person in 2007-08 and highest employment was recorded in 2016-17(20800nos. of persons). The percentage of coal share to total coal production of India has increased from 2003-04 to 2009-10 and again showing an increasing trend form 2013-14 to 2016-17. And compound annual growth rate (CAGR) of coal production is 17.82.

## 4. ENVIRONMENTAL IMPACT AND SUSTAINABLE DEVELOPMENT

The magnitude and extent of environmental cost caused by coal mining depends on the type of pollutants, their chemical properties and concentration in the air and water. All the pollutants have damaging effect on forest and biodiversity, vegetation, human health and cattle health (Berry & Hurton 1974). Several studies have found that diseases namely asthma, chronic bronchitis, respiratory trouble, blockage of psycho-motor function, gastro-intestine diseases and so on can be attributed to the air and water pollution caused by coal mining (OSPCB, 1996; Hota and Behera, 2015). Sources of air pollution in coal mining areas generally include drilling, blasting, loading and unloading, and exposed pit faces etc. (CMRI, 1998). In the coal mine area of Angul-Talcher, one of the 22 pollution hotspots in India, the pollution is due to very high intensity of coal based pollution. The activities like drilling, blasting of coal, dump formation; transport activities reduce

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dust and noxious gases which degrades the air quality. The fly ash and pollutants when mixed with water bodies led to water pollution (GOO, 2008).

Table 5 shows the numbers of coal based power plant, their coal consumption and fly ash generation. The fly ash generated in 2010-11 was 9.05 million tonnes and highest fly ash *generated 14.1534 million tonnes in* 2013-14. The fly ash utilisation varies from 3.3419 million tonnes to 6.3975 million tonnes. The fly ash utilisation was not even 50% except in 2016-17 and 2017-18.

**TABLE-5: FLY ASH GENERATION AND ITS UTILIZATION IN ODISHA**

| Year | Nos. Of TPS | Capacity (MW) | Fly Ash Generation (mtpa) | Fly ash Utilisation (mtpa) | Percentage Utilisation |
|---|---|---|---|---|---|
| **2010-11** | 3 | 3880.00 | 9.05 | 3.76 | 41.53 |
| **2011-12** | 4 | 5680.00 | 10.66 | 3.63 | 34.01 |
| **2012-13** | 4 | 6280.00 | 11.69 | 5.30 | 45.34 |
| **2013-14** | 7 | 8788.00 | 14.15 | 6.76 | 47.75 |
| **2014-15** | 5 | 5188.00 | 10.02 | 4.91 | 49.00 |
| **2015-16** | 5 | 5188.00 | 10.95 | 5.39 | 49.30 |
| **2016-17** | 5 | 5188.00 | 11.46 | 6.39 | 55.84 |
| **2017-18** | 6 | 6388.00 | 6.47 | 3.34 | 51.63 |

Source: CENTRAL ELECTRICITY AUTHORITY, New Delhi, Government of India

**TABLE-6: DEFINITION OF THE VARIABLES**

| Name of the variables | Explanations |
|---|---|
| **Dependent** | |
| Fly Ash Utilisation | Fly ash utilisation in million tonnes per annum |
| **Independent** | |
| Fly Ash generation | Fly ash generation by coal thermal plants in million tonnes per annum |

**TABLE-7: REGRESSION RESULT**

| Sl. No. | Intercept, Model Test Measure | Values of the Coefficient (P-value) |
|---|---|---|
| 1 | Intercept | -0.163(0.909) |
| 2 | Fly Ash generation | 0.483(.009)** |
| 3 | $R^2$ | 0.704 |
| 4 | R | 0.839 |
| 5 | F | 14.245 |
| 6 | P-Value | 0.009 |

**** Statistically significant at 1% level**

Table 6 and table 7 shows the definition of regression model and result respectively. The model is found to be significant with a high value of $R^2$ at 0.704 therefore model is indicating goodness of fit. 70 percent variation in fly ash utilisation(Y) explained by the variation fly ash generation(X). The estimated regression line is

$\hat{y} = -0.163 + \quad 0.483X_{it}$

s.e. (1.377) (0.128)

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**TABLE-8: YEAR WISE AMBIENT AIR QUALITY IN MAHANADI COAL FIELD IN ODISHA ($MG/M^3$)**

| Year | Sulphur Dioxide ($SO_2$) | Nitrogen Oxide ($NO_2$) | Suspended Particulate Matter (SPM) | Respirable Suspended Particulate Matter (RSPM) |
|---|---|---|---|---|
| **2006** | 9 | 19 | 162 | 84 |
| **2007** | 10 | 15 | 202 | 90 |
| **2008** | 14.3 | 24 | 237 | 102 |
| **2009** | 14.1 | 26.8 | 267 | 115 |
| **2010** | 13.4 | 26 | 268 | 135 |
| **2011** | -- | -- | -- | -- |
| **2012** | -- | -- | -- | -- |
| **2013** | 8.9 | 20.7 | 221 | 114 |
| **2014** | 9.2 | 23.8 | 262 | 135 |

Source: Compendium of Environment Statistics, 2016, Directorate of Economics and Statistics, GOO.

Table 8 shows annual average value of Sulpher Dioxide ($SO_2$) remain within the limit (50 $\mu g/m^3$) in Mahanadi coal field area. Nitrogen Oxide ($NO_2$) annual average value is also within the limit (40 µg/m3). Regarding Suspended Particulate Matters (SPM) concentration at Mahanadi Coal Field Area is higher than other areas during the year 2014-15. Similarly, in Respirable Suspended Particulate Matter (RSPM), Mahanadi Coal, monitoring station is higher than other areas during 2014-15.

## 5. CONCLUSIONS

Coal serves as the only natural resources and fossil fuel available in abundance in India and Odisha. Coal mining provides stream of economic benefits in terms industrialisation, employment and revenue to government. But at the same time it causes air, water and noise pollution, biodiversity loss, ecological loss etc. there are various health problems are facing by local people due to coal mining are fevers, gastritis, skin diseases, joint pain and, also cases of weakness, cough and cold, asthma and gynaecological problems. Fly ash generation by thermal power plants are causing serious problems. Fly ash utilisation is not satisfactory. Therefore, careful planning must needed to reduce the environmental damage. Then only sustainable coal mining is possible.

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