Dynamics of Coal Extraction in Meghalaya and its Implications

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Introduction

Stock of natural resources, both renewable and non-renewable, has been seen as determinants of national wealth and growth. In other words, differences in resource endowments have been perceived to be influencing income and prosperity differential between any two countries. Therefore the long run prospects of an economy have been subjected to such constraint supply of natural resources, especially the exhaustible resources. Long back, Meadows in his *Limits to Growth* already raised doubt about the sustainable growth of the economies because of the exhaustibility of the natural resources, especially the critical exhaustible natural resources (Meadow *et al.*, 1972). The notion was that, continuous extractions of exhaustible resources like coal, petroleum etc., which are the main source of energy and other material resources to meet the increasing need of the growing population will raise the scarcity of those resources and thereby it would halt growth process.

The path-breaking works completed in 1960s and 1970s, where the economists systematically investigated the efficient and optimal depletion of resources, both renewable and non-renewable. The original works on optimal depletion of exhaustible resources however dates back to Gray (1914) and the classic paper by Hotelling (1931), which provided a foundation upon which the later resource economists like Dasgupta and Heal (1979), Solow (1974, 1986) and Hartwick (1977, 1978, 1995)

developed their more general and extended the structure of analysis. Though the market economists gave their counter-argument against the principle of *Limits to Growth* that the rising cost or prices of existing exhaustible resources would lead to the development of the substitutes available at relatively cheaper rate and the growth process would not stop; there is no denying of the importance of some natural resources like coal, petroleum etc. However, there have been continuous efforts across the countries for making the principle of weak sustainability a real one through the continuous improvement of technology and the human resources. The development of human resources always helped in this regard throughout the human history and that is why in spite of having the highest population size in the world with modern standard of living the economies are still growing. But there has always been a fear psychosis among the people who are largely concerned about the management of natural resources and other environmental problems cropped up from the development activities. Also there is an uncertainty about how far the substitutability of those resources will be possible in reality. Moreover, there is the time lag after which the substitutes become available and if that period is long enough one should not wait and continue to extract in an inefficient way so that the particular resource will exhaust before the arrival of its substitutes in the market. A question also remains there as how to ensure the market that can operate freely and perfect transfer of technology, resources etc., so that there will be no mis-allocation of resources in the market. For inter-temporal choice of resource use to attain dynamic equilibrium Hotelling path gives us the guideline how to choose the rate of extraction that will optimise the desire of the society to utilise a particular resource.

A model of pure depletion gives $\dot{R}(t) = -q(t)$, where $\dot{R}(t)$ represents the remaining reserves, q(t) the harvesting of resource. If X(t) is the cumulative discoveries and W(t) be the exploratory efforts, the dynamics of non-renewable resource with exploration is given by $\dot{R}(t) = \dot{X}(t) - q(t)$, and $\dot{X}(t) = f\{(W(t), X(t)\}$, where normally $f_w > 0$ and $f_x > 0$ (Pindyck, 1978, p. 844). If price of the resource follows $P_t = P_0\ e^{st}$ then the owner will be indifferent between extracting and selling the resource at present with price P_0 and extracting the same after t years with price $P_0\ e^{st}$ (Hotelling, 1931, p. 141). In equilibrium quantity of extraction must be

equal to the demand i.e., q(t) = D (P(t)). If the extraction goes on in such a way and it exhausts after T years i.e., $\sum_{t=0}^{T} q(t) = R$ and demand at price P_t will be zero i.e., q(T) = D ($P_0 e^{st}$) = 0 (Conrad and Clark, 1987, Chapter 3). The Hotelling rule for optimal extraction of an exhaustible resource thus states that $\frac{\dot{p}}{p} = s$. That is resources should be extracted in such a way that the rate of growth of price of the extracted resource should be equal to the social rate of discount. If C is cost per unit of resource extraction then the optimal extraction is governed by $\frac{\dot{p}}{p-c} = s$, where P–C is the royalty of resource extraction. In other words, optimal price is equal to the marginal extraction cost plus marginal user cost.

Coal Reserve and its Importance on the Economy of Meghalaya

Coal is one of the important exhaustible resources of the state of Meghalaya. It has an important bearing on the economy of the state. The coal extraction and its related activities have been contributing a considerable portion (around 20 per cent) of state domestic product. Here coal is estimated to be available within 300 metres of depth under the soil. The total proved stock of the state's coal reserves is around 118 million tonnes. Total reserves including indicated and the inferred quantity is about 564 million tonnes. But it is yet uncertain whether the indicated and inferred amount would be economically exploited or not. Though coal is found all over Meghalaya, majority of the deposits occurs in Garo Hills. The spatial distribution of deposit is given in Table-1.

The extraction of coal in Meghalaya has been started more than hundred years back. Though in other areas of North-East India, coal was extracted to meet the requirements of railway, tea processing industry, brick kiln along with domestic need; in Meghalaya the production was mainly for the domestic use (Deka, 1998). A limited portion was used in the industries. Even in many parts of the state, the deposits were not properly accessed. The available record shows (Appendix-1) that the extraction was going on a very minor scale since 1960s, which

Table-1: Spatial Distribution of Coal Deposit in Meghalaya (Mn Tonnes)

Places of Deposit	Quantity	Uses
Khasi Hills: Laitryngew, Cherrapunjee, Laitduh, Mawbehlarkar, Mawsynram, Lumdidom, Langrin, East Darrangiri, Pynursla, Lyngkyrdem, Mawlong-Shella-Ishamati and Borsora	164.50	Power Generation, Fertiliser Manufacturing., Smokeless Coke, Cement, Textile, paper, Rubber, Brick and Pottery Industries.
Jaintia Hills: Bapung, Lakadong, Sutnga, Jarain, Musiang Lamare, Toksi, Khliehriat	40.00	
Garo Hills: West-Darrangiri, Siju, Balpakram, Selsela, Pyndengrei	359.00	
Total	563.50	

Source: (1) Technical Data on Minerals, Directorate of Mineral Resources, Meghalaya Quarterly Journal on North-Eastern States Economy — Vol. 1, July 2002, North-Eastern Development Finance Corporation.

had been very small in quantity and through open cast mining process with the help of manual labour.

Large-scale extraction has been started on an increasing scale since 1978 and the production is to meet not only the domestic need of the local people but also for the export to other regions of the country and substantial portion to neighbouring Bangladesh. Over the years, quantity and export earning has been increasing. Though earlier export price was administered and pegged at $ 40 per MT, from 1998 it has been deregulated and left to market forces to determine the price. However, despite differences in price of coal exported from different custom stations we do not find any significant changes in price of coal and even now Bangladesh is importing coal from Australia at a relatively higher rate ($ 56 per MT) because of its good quality and its utility in the chemical industries. Whereas coal of Meghalaya is of moderate quality (sub-bitumimes and lignite) and used mainly in cement, brick kiln, tea garden and some other small-scale industries.

Apart from its contribution to the State's income in the form of royalty, coal is the largest export earner of Meghalaya. Now around 14 lakh tonnes of coal are exported to Bangladesh annually, which fetch over Rs. 254 crore as calculated by the authors (from the figures on export quantity through different land custom stations and total value of it). The value and quantity of export to the other region of the country is not included here,

Table-2: Export of Coal from Meghalaya to Bangladesh during 1998-2004

Year	Export (Lakh MT)	Value (Rs. in Crore)	Price (Rs./MT)
1998	6.12	90.54	1479.11
1999	5.45	96.07	1763.68
2000	7.43	127.98	1722.53
2001	8.97	166.11	1852.27
2002	10.71	188.51	1760.65
2003	12.23	226.46	1852.30
2004	13.84	254.36	1837.84

Source: Quantity and Value collected from different land custom stations. Price figures are the average values at which exports have been taking place, estimated by the authors.

which would be around 78 per cent of the total production as per estimates of the authors. Though Bangladesh also imports from other countries, export from Meghalaya also increased over the years due to rising demand in that country. The export has been more than doubled during 1998 to 2004 only as shown in Table-2.

Not only quantity of export, value of export has also increased by over 180 per cent during 1998 to 2004. The deregulation of export price after 1998 has not caused any damage. Though price is determined by the market forces the exporters are rather benefited due to rise in average value at which coal has been exported. However the rate of growth of price has been very slow, fewer than three per cent per annum compared to any other resource or market rate of interest.

Considering the fact that three labourers are required for the extraction of one MT of coal, in 2004 around 163 lakh man-days have been generated directly in extraction. In other words, over 90,650 workers were directly engaged in mining activity considering 180 days working possible in a year of which, around 90 per cent are outsiders and merely 5 per cent are from local areas. The information is gathered from a sample survey of 200 labourers by the authors in Jaintia Hills District. Moreover there is indirect employment generated in the allied sectors of coal, which is in fact much more than the direct employment.

Here extraction is done through surface mining process popularly known as the rat hole method. Now, gradually mechanical devices have been employed and we observe rather reduction in the unit cost of extraction, though at very slower

rate. It is natural that with the increase in extraction, availability declines and also the difficulty of exploitation rises with the unchanged technology and thus cost of extraction rises. But in Meghalaya we observe rather reduction in cost of extraction due to the mechanisation though it has been going on a very slow pace. This is also due to the economies of large-scale operation. Though the quality of coal is not of very high standard, due to increase in scarcity in other regions of the country and improvement of communication, coal of Meghalaya is being exported to other regions where it is mixed with the good varieties for industrial use. Most of the mines are actually owned by the private individuals (though there is an understanding that the resources are owned by the community), where it is normal that they will be guided by the profit maximising principle and hence utilise the resource judiciously. Whereas, we observe over-exploitation of coal (Appendix-1), as is happened in case of open access common property resources. Therefore the objective of this paper is to examine, if the current trend of extraction continues, how long the present estimated stock would last and what would be possible consequences of such extraction. Moreover, we would like to throw light on the possible implications of coal extraction on the economy of Meghalaya.

Methodology

The data on extraction of coal in Meghalaya, which have been presented in Appendix-1, has been collected from the Directorate of Mineral Resources, Government of Meghalaya. It was available for the period 1961–62 to 2005–06. For the sake of analysis, we have first considered the extraction of coal in Meghalaya from 1978, since when we observe a systematic pattern of extraction over time and extraction started commercially. Considering the cumulative total extraction over the years from 1978 to 2005 we fitted a model of the type $\text{Ln } Y_t = \alpha + \beta t \ldots (1)$. Where Y_t is cumulative total extraction up to time t i.e., $\sum_{k=0}^{t} Y_k$ and α, β are the two parameters. Here β represents the exponential rate of growth of cumulative extraction of coal over the years. Here semi log linear equation is fitted after the careful examination of the scatter diagram of the actual time series data. After estimating the pa-

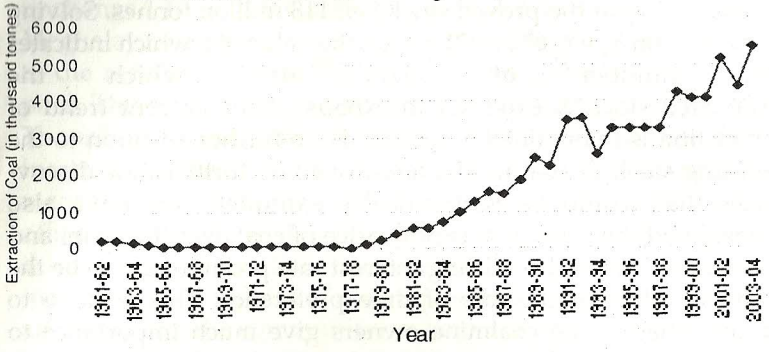
rameters of the equation by the ordinary least square method we put the values of the parameters in the equation and estimated Y is equated with the proved stock i.e., 118 million tonnes. Solving the equation $Y_t = Y_0 e^{\beta t}$., ...(2) we get the value of t, which indicates the number of years after which the estimated stock is expected to exhaust if the current trend of extraction is maintained and there is no further addition to the existing stock of coal in Meghalaya i.e., no further new discoveries that would be economically exploited. We have also considered the growth of export price of coal over the years and compared it with the existing interest rate presuming it to be the representative of the rate of time preference. This is done to know whether the coalmine owners give much importance to the future or in what way they value the future stock. Though the data on price was not available directly, here we have calculated the price after dividing the total sales proceeds by the quantity of extraction of a few years from 1994 to 2002 that were available from different sources and compound growth rate has been calculated. Here due to scarcity of sufficient data, time series regression has not been possible. For estimating workers we followed simple random sampling method and taken information from the 200 mine-workers from Jaintia Hills District about their origin, income and other socio-economic background. Also census method is used in the same area to gather information from the mine owners and people involved in coal related activities. From those information we estimated total direct and indirect employment due to extraction of coal in the state as a whole.

Results and Discussion

Data presented in graph-1 shows that the rate of extraction of coal in Meghalaya was at much lower scale before 1978–79. Moreover, the extraction was declining over the years and in 1977–78 it was only 10 thousand tonnes due to the social disturbances and non-availability of mine workers. Since 1978–79 there is increasing rate of growth of coal extraction in the state. Graph-2 shows the increasing rate of growth of extraction of coal. After using OLS method we observe that the annual exponential rate of growth of cumulative extraction is 19.94 per

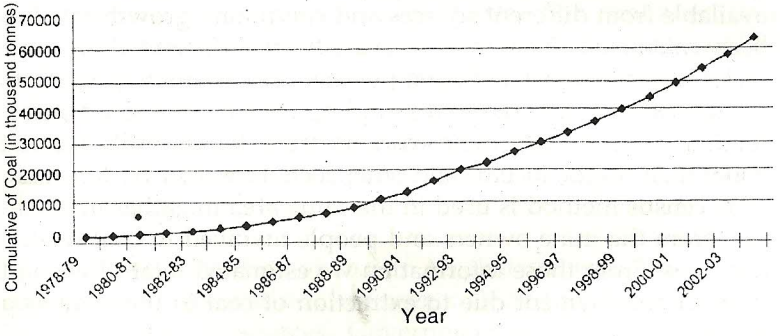
Graph 1

Extraction of Coal in Meghalaya over time



Graph 2

Cumulative total Extraction of Coal in Meghalaya since 1978



cent, which is highly significant. The estimated equation is LnY = 6.43 + 0.1994 t...(3)

(0.014), (R^2 = 0.89)

The term in the bracket indicates the standard error of the β. Putting estimated Y equals to 1,18,000 thousand tonnes, and solving the equation we get the value of t as 34.50 that is around 35 years. Even if we assume that some amount had already been extracted before 1978 and we deduct it from the estimated 1,18,000 thousand tones available stock and equate with the cumulative stock, we get the result as t equals to about 34. There is not much difference in the result, because the cumulative total extraction up to 1978 was very small in quantity with respect to

the available resources. Please note that we have not used the estimated value of LnY_0, rather we have used the actual value of Y_0 and only the value of estimated growth rate is taken into consideration. Even if the total possible reserve can be economically harvested with the depletion of stock over time, it would last some where around forty-three years. As 27 years have already elapsed since 1978, the remaining reserve may survive for another 15–16 years.

Annual average compound growth of that price is calculated to be around six per cent from 1994 to 2002 (the average of growth after deregulation of price since 1998 is even lower than that). This was much lower than the long-term interest rate (though declining) in the commercial banks existing during that period. This was an indication of lower time preference of the coalmine owners for the future than what it would have been. That means they are not much concerned about the preservation for the future and they value their present welfare more than the future. Or they may earn more if they invest their earning from mine in other ventures or simply put in the bank as long term fixed deposit.

Implications for the Economy of Meghalaya

The state of Meghalaya has been generating substantial revenue from the extraction of coal in the form of royalty over the years. It has been over ten percent of its total internal receipts. Table-3. shows that the amount of royalty, which has been a function of

Table-3: Royalty from the Export of Coal as Percentage of Total Internal Revenue Receipts of Meghalaya since 1994–95

Year	Percentage
1994–95	5.09
1995–96	12.72
1996–97	12.47
1997–98	8.77
1998–99	12.70
1999–2000	10.05
2000–01	15.28
2001–02	14.47
2002–03	10.26

Source: Directorate of Statistics and Economics, Government of Meghalaya.

changes in the rate of royalty and extraction over time, has been fluctuating. But we noticed an overall increasing trend and it has been the highest in 2000–01, when the earning was over 15 per cent of total state revenue. Therefore, if coal is exhausted or become redundant then the state will lose around 10 per cent of its total revenue earned from coal directly. However, it does not guarantee an overall loss as, if the policy of preservation is undertaken then the state will have to lose the current royalty earning, which, has been rising at the rate not lesser than the social rate of discount. So, if the current earning is invested properly in alternative sectors so that it generate sufficient cumulative benefit in future it will improve future prospect of the economy than if it is preserved.

Moreover, there are the indirect benefits as the private owners may invest in alternative sectors to generate sufficient resources from where also state may earn tax revenue and that may generate employment. Practically, most of the coal mine owners are not much interested in investing in industries rather, they depend much on interest earning in the bank and real estate where from they can earn rent and similar other risk free ventures. Hence there is a doubt how much of this will generate future employment to offset the loss in employment once coal is exhausted and will contribute to the over all progress of the state. Thus what will be exact impact on the future economy of the state can be judged only after knowing the rate of prospects of alternative sectors that would come.

In case of employment, as we have noted earlier that around 90,652 labourers were directly involved in mining in 2003–04 of which around 86,120 were outsiders and 4,532 were locals from all Jaintia, Khasi and Garo communities. In addition to that, by using census method we found 16,510 people from the state who are involved in coal mining and trading activities in Jaintia Hills in different capacities such as coal mine owner, coal agent, depot owner, depot manager, middle man, trader, truck owner, driver, handyman, international exporters and their managers etc. In the state as a whole, approximately 22,919 persons are either directly or indirectly involved in coal mining and trading activities, all of which are from Meghalaya. Moreover there are around 4,532 local mine labourer. So a total of around 27,451 local individuals are engaged in those aforesaid activities. In

aggregate, at least 1,13,571 employments have been generated at present that are from the state as well as from the other regions like Assam, Bihar, Nepal etc. In addition to that, there are some small businesses like grocery shops, tea stalls and phone booths etc. developed in the mining sites and many people from the neighboring areas are engaged in such activities. The employment will proportionately increase over time if labour saving technology is not used. Therefore after the exhaustion of coal after two or three decades, it would have serious implication on the employment situation unless sufficient alternative opportunities are created in other sectors.

Also the exhaustion of coal will have adverse impact on the allied industries like cement, brick kiln etc. where coal is used as input significantly. Also for energy the economy will have to depend on alternatives like gas, hydro, oil or nuclear sources, as presently in the country around 69 per cent of energy is generated from coal though in Meghalaya electricity is mainly generated from water (John, 2000). If gas and oil are to be imported then it will have serious impact on balance of trade. Moreover, exhaustion of coal will also have impact on the export earning of the state as a significant portion of export is composed of coal as shown earlier.

Conclusion

From the overall analysis it becomes clear that if the current trend of exploitation of coal in Meghalaya is continued then it will not survive for a long period. Even if we assume that a considerable portion of indicated and inferred stock will be available, it will not take much time to exhaust the deposit of coal under Earth surface of Meghalaya, unless judicious approach is adopted to utilise the same. Though in many countries technologies have been changing to find alternatives of coal (for rising cost and fear of exhaustibility as well as to avoid the rising pollution problem due to huge combustion of coal), in India coal is still being extensively used for domestic purposes (for cooking, in fireplaces of hilly areas etc.), in iron and steel, cement and other industries and also in thermal power projects. India will have to go a long way to obtain economically full-scale substitutes of coal either on its own or from the advanced

countries. Therefore a judicious approach is well warranted in the utilisation of coal.

Secondly, 44 years is not long enough of which two and a half decades have already gone. Even though we assume that it would not be possible to maintain this rising trend of extraction after some years and it would last a few more years, that will not be long enough, which can allow the next generation of those mine owners to survive only on the naturally supplied stock of coal without searching for and investing in alternative opportunities. It is also not a healthy symptom for the economy of the region.

Thirdly, it is apparent that there are a few owners of the total coal reserves of Meghalaya and they must be operating like a cartel. But here the situation is not like so. Because the experience says that these few owners are enmeshed in competition among themselves to exploit as much as possible quickly and becoming rich over night and also to maintain a luxurious lifestyle. So they give more importance on their present consumption needs than the future. So it is a case of competition among the few who are moving along the conflict locus of Stackleberg's oligopolistic model. All of them are trying to produce more and making more revenue whatever be its implication on price and per unit royalty. Which may be one of the reasons of slow rise in price of coal compared to the social discount rate. Also the over extraction may be due to the fear of losing the ownership right that always haunts the proprietors as major minerals in other parts of the country are public property and in North-East still now the community enjoys the ownership right.

Fourthly, a few of them may be interested in investing money in the bank for earning interest income or invest in real estate around Shillong or other places to raise rental later and sustain on that. But these efforts would not help in the development of alternatives to coal that would help continuous progress of industries and thus economies. Moreover, there is the possibility of loss of job opportunities in such mining and related activities.

Finally, though we could not say much about what would be the optimal rate of extraction for which we need the concrete data on prices for a considerable period of coal and its substitutes and the development in the substitutes of coal and its related industries, transfer rate of alternative technologies from the other

countries, trend of new finds in the other region of the country etc., one can safely argue for the need of judicious approach in the extraction rate and investment for the development of employment generating resources in the region. Moreover, there is much scope for the development of research in this line. In conclusion, we can say that coal should be used increasingly for the current progress and stress should be given to improve technology and human resource to mitigate the future problem that may occur from the exhaustibility of coal resources in Meghalaya.

Appendix-1

Quantity of Extraction of Coal in Meghalaya during 1961–62 to 1993–94 (Thousand tonnes)

Year	Quantity	Year	Quantity
1961–62	220	1983–84	713
1962–63	215	1984–85	949
1963–64	176	1985–86	1265
1964–65	102	1986–87	1507
1965–66	79	1987–88	1436.2
1966–67	54	1988–89	1855.5
1967–68	40	1989–90	2446.8
1968–69	37	1990–91	2241.3
1969–70	34	1991–92	3464.3
1970–71	39	1992–93	3486.7
1971–72	61	1993–94	2546.5
1972–73	63	1994–95	3226.2
1973–74	56	1995–96	3247.5
1974–75	53	1996–97	3240.9
1975–76	59	1997–98	3233.5
1976–77	29.8	1998–99	4237.6
1977–78	10	1999–00	4060.1
1978–79	122	2000–01	4064.9
1979–80	196	2001–02	5149.3
1980–81	362	2002–03	4396.2
1981–82	521	2003–04	5439.1
1982–83	548	2004–05	5345.2
		2005–06	5565.7

Source: Directorate of Mineral Resources, Government of Meghalaya.

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