Integrated Economic and Environmental Accounting of Mineral Resources in India

By
DASARATHI PADHAN

Enrolment No: APSA11201704002

National Institute of Science Education and Research, Bhubaneswar

A thesis submitted to the

Board of Studies in Applied Systems Analysis

In partial fulfillment of requirements

for the Degree of

DOCTOR OF PHILOSOPHY

of

HOMI BHABHA NATIONAL INSTITUTE

March, 2023

Homi Bhabha National Institute[1]

Recommendations of the Viva Voce Committee

As members of the Viva Voce Committee, we certify that we have read the dissertation prepared by **Dasarathi Padhan** entitled **"Integrated Economic and Environmental Accounting of Mineral Resources in India"** and recommend that it may be accepted as fulfilling the thesis requirement for the award of Degree of Doctor of Philosophy.

Chairman - Dr. Pranay Swain	[signature]	Date 28 July 2023
Guide / Convener – Dr. Amarendra Das	[signature]	Date 28-07-2023
Co-guide -		Date
Examiner – Prof. Saudamini Das	[signature]	Date 28-7-23
Member 1- Dr. Amarjeet Nayak	[signature]	Date 28-7-23
Member 2- Dr. Joe Varghese Yeldho	[signature]	Date 28/7/23
Member 3- Prof. Mitali Chinara	[signature]	Date 28/7/2023

Final approval and acceptance of this thesis is contingent upon the candidate's submission of the final copies of the thesis to HBNI.

I/We hereby certify that I/we have read this thesis prepared under my/our direction and recommend that it may be accepted as fulfilling the thesis requirement.

Date: 28-07-2023

Place: Bhubaneswar

[signature]

(Dr. Amarendra Das)

Guide

[1] This page is to be included only for final submission after successful completion of viva voce.

STATEMENT BY AUTHOR

This dissertation has been submitted in partial fulfillment of requirements for an advanced degree at Homi Bhabha National Institute (HBNI) and is deposited in the Library to be made available to borrowers under rules of the HBNI.

Brief quotations from this dissertation are allowable without special permission, provided that accurate acknowledgement of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the Competent Authority of HBNI when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

Dasarathi Padhan

Dasarathi Padhan

DECLARATION

I, hereby declare that the investigation presented in the thesis has been carried out by me. The work is original and has not been submitted earlier as a whole or in part for a degree / diploma at this or any other Institution / University.

Dasarathi Padhan

Dasarathi Padhan

DECLARATION

I, hereby declare that the investigation presented in the thesis has been carried out by Dasarathi Padhan under my supervision. The work is original and has not been submitted earlier as a whole or in part for a degree / diploma at this or any other Institution / University.

Dr. Amarendra Das

List of Publications arising from the thesis

Journal

1. "Physical and monetary asset accounting of mineral resources in India", Dasarathi Padhan and Amarendra Das, *Resources Policy*, 2022, Vol.78, 102902. https://www.sciencedirect.com/science/article/abs/pii/S0301420722003464

2. "Environmental Accounting in India: Progress and Challenges", Dasarathi Padhan and Amarendra Das, *Economic and Political Weekly,* 2021, Vol. LVI.,46-52 https://www.epw.in/journal/2021/31/special-articles/environmental-accounting- india.html

Chapters in books and lectures notes

1. **Padhan, D.** (2021). Wealth Accounting of Mineral Resources in India: A Necessary Step towards Sustainable Development. In *Sustainable Development and Environment: Issues and Challenges*, Patra, S.; Das, S.; Behera, B.C.; Singh, P., and Mishra, D. (Eds), New Delhi: Kunal Books, Page: 264-280.

Conferences

1. 'Measuring the Real Contribution of Coal Mining in India: Environmental Accounting for the Sustainable Use of the Natural Resource' at the 25th annual conference of the Association for Heterodox Economics, Anglia Ruskin University, Cambridge, 28th-30th June, 2023.

2. 'Green National Accounting: The Case of Coal Mining in India' at annual conference of the Indian Association for Research in National Income and Wealth (IARNIW), New Delhi, 17-18, March, 2023.

3. 'Environmental cost adjusted national accounts for coal mining in India' SANEM annual economists' conference, Dhaka, Bangladesh, 4-5 Feb, 2023.

4. 'Environmental Accounting of Mineral Resources in India Using SEEA Framework' at Doctoral Colloquium on Management and Development, IRMA, Gujarat, 15-17, Nov, 2021.

5. 'Natural Capital Accounting: Case of Mineral Resources in India, 1995-2015' at 17th GLOBELICS international Conference organized by CINPE and UNA, Costa Rica, 3-5 Nov, 2021.

6. 'Natural Capital Accounting; Case of Mineral Resources in India, 1995-2015' at ISEE-ESEE-Degrowth 2021 Conference hosted by University of Manchester (UK), 5-8 July, 2021.

7. 'Wealth Accounting of Mineral Resources in India: A Necessary Step towards Sustainable Development' at International Conference on Development, Environment and Sustainability, Berhampur University, India, 22-23 Feb, 2020.

8. 'Construction of Physical and Monetary Asset Accounts of Mineral Resources in India using SEEA Framework' at Orissa Economics Association annual conference 8-9 February, 2020.

Poster Presentation:

1. 'Natural Capital Accounting: Case of Mineral Resources in India, 1995-2015' with Amarendra Das, at official twitter of Ministry of Statistics and Programme Implementation, 15th Jan, 2021.

Dasarathi Padhan

Dasarathi Padhan

I dedicate this thesis to my parents.

ACKNOWLEDGEMENTS

I would like to thank all the people who directly and indirectly helped me writing the thesis. I believe, Writing thesis is a social process. My sincere gratitude to all who were part of this process. I am grateful to Dr. Amarendra Das for the guidance to carry out this research work. Thank You, everyone.

Table of Contents

Summary

(1) This research focuses on the environmental accounting of the mineral resources in India. A brief historical discussion on the studies of environmental accounting in India indicates that though government of India has initiated several studies on natural resource accounting, we are far away from measuring inclusive wealth and green GDP. The government has been publishing Environmental Statistics on physical stocks of different natural resources. Valuation of all these resources is needed to calculate the wealth and to integrate the environmental aspects to economic accounting.

(2) The value of mineral production has gone up of since the independence. Among the mineral rich states Odisha contributes the most to the value of mineral production. Gross Value Added (GVA) of mining and quarrying sector has been increasing but its share to total GVA of the Indian economy has gone down since 1991-92. Total employment in mining has also declined since 1992. I find a large gap between number of the men and women working in the sector. It has always been male dominated sector. Negative trade balance of the mining sector is growing.

(3) The reserves of iron ore, manganese ore and bauxite in India have declined from 1995 to 2015. In physical terms, production or extraction of all the three minerals have increased significantly from 1995 to 2015. The extraction rate of bauxite has been much higher than iron ore and manganese ore. Though all the minerals gave negative resource rents to the economy in 1995, they turned positive in the subsequent years. Resource rents have increased remarkably. Because of negative resource rent in 1995, the Net Present Value (NPV) of all minerals was negative in 1995. Overall, the NPV of the resources has risen from 1995 to 2015 barring a slow down during 2005 to 2010. The substantial rise in the

NPV and resource rent of all three minerals after 2010 can be explained by the drastic rise in the prices of minerals driven by global demand.

(4) The depletion or User's cost of coal mining is zero in all the years from 2004 to 2015. It is because the life index of coal reserves for all the years is high. However, the life index is declining throughout the years in consideration. The total methane emission from coal production has increased from 2004 to 2015. Methane emission from surface mining has a significant share in the total emission. The environmental cost as percentage of GVA from mining and quarrying varies from 4.5 per cent to 3 per cent.

(5) In the states of Assam, Chhattisgarh, Goa, Jharkhand, Meghalaya, Rajasthan, and Telangana the drastic increase in the expenditure on health and education has helped in converting the negative genuine saving into positive. Reduction in mineral production in these states has also contributed in this transition. Except Odisha all other states have reported positive genuine saving during the latest years. Out of eleven mineral rich states, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, and Tamil Nadu never reported negative genuine savings. State like Kerala which is known for its investment in human capital and which is not a mineral rich state has surpassed, in generating genuine saving, so many mineral rich states such as Andhra Pradesh, Chhattisgarh, Goa, Jharkhand, Madhya Pradesh, Odisha and Rajasthan.

List of Figures

Page No.

List of Tables

Page No.

List of Abbreviations

AR5:	Assessment Report 5
BEA:	Bureau of Economic Analysis
CFC:	Consumption of Fixed Capital
CIMFR:	Central Institute of Mining and Fuel Research
CoE:	Compensation of Employees
CSO:	Central Statistical Office
E_Cost:	Environmental Cost
EGVA:	Environmentally Adjusted Gross Value Added
EPWRF:	Economic and Political Weekly Research Foundation
ESDP:	Environmentally Adjusted State Domestic Product
FDES:	Framework for the Development of Environment Statistics
GDP:	Gross Domestic Product
GED:	Gross External Damages
GFCF:	Gross Fixed Capital Formation
GNP:	Gross National Product
GOS:	Gross Operating Surplus
GSDP:	Gross State Domestic Product
GVA:	Gross Value Added
HDI:	Human Development Index
HVP:	Hoteling Valuation Principle
IBM:	Indian Bureau of Mines
IC:	Intermediate Consumption
IPCC:	Inter-governmental Panel on Climate Change
M&Q:	Mining and Quarrying
MCDR:	Mineral Conservation and Development Rules
NDP:	Net Domestic Product
NED:	Net External Damages
NFCS:	Net Fixed Capital Stock
NNP:	Net National Product
NPV:	Net Present Value
NSDP:	Net State Domestic Product
NSO:	National Statistical Office
PPP:	Purchasing Power Parity
RBI:	Reserve Bank of India
RV:	Resource Value
SDG:	Sustainable Development Goals
SDP:	State Domestic Product
SEEA:	System of Environmental-Economic Accounting
SSGDP:	Socially Sustainable Gross Domestic Product
TERI:	The Energy Research Institute
UN:	United Nations
UNFC:	United Nations Framework Classification
UNSNA:	United Nations System of National Accounts

Glossary

Access Price Method: Assets are valued by the purchases of licenses and quotas. Government may give free access extractors or may give at a price less than market value. Trading of the markets may be prohibited or restricted. In that case, these is no market valuation.

Appropriation Method: Assets are valued by the actual payments made to owner of the environmental asset. These payments are the fees, taxes, and royalties paid to the government. These payments understate the total resource rent as these rate may be set, keeping in mind, to encourage the private investment and employment in extractive industries.

Dutch disease: It is a concept to explain the relationship between the resource extraction and economic development. It says that the booming natural resource sector can lead to decline in the other tradable sectors like manufacturing and agriculture. It reflects the imbalance among the different sectors due to discovery of natural resource. This occurs because of the disproportionate amount of labour diverted to the natural resource sector withdrawing from the manufacturing sector. The export competitiveness becomes worse because of the appreciation of real exchange rate.

Environmental Accounting: Integration of environmental accounting in conventional national accounts.

Genuine Saving: It is a measure of sustainably. It consists of investment in produced assets and human capital less the value of depletion of natural resources.

Hotelling Principle: Along the optimum extraction path, where the resource owner is indifferent as to the options of extracting or leaving the resource in ground, the price of the resource, net of marginal extraction costs, that is, the user cost has to rise at a rate equal to the discount rate.

Net Price Method: Volume of reserve existing multiplied with the difference between the average market value and the cost of production per unit of the resource.

Net Present Value: it is the discounted value of the future expected return. It is an alternative to market price approach. It is consistent with the system of national account.

Sustainable Development: Development that meets the needs of the present, without compromising the ability of the future generations to meet their own needs.

User Cost: Price of the resource net of marginal extraction cost. (UC= P-MC)

Wealth: Social value of the entire productive base of the economy. It comprises of produced capital, human capital, natural capital, population, public knowledge, and institutions.

Written Down Replacement Method: The current acquisition price of an equivalent new asset less the accumulated consumption of fixed capital over its life.

Chapter 1

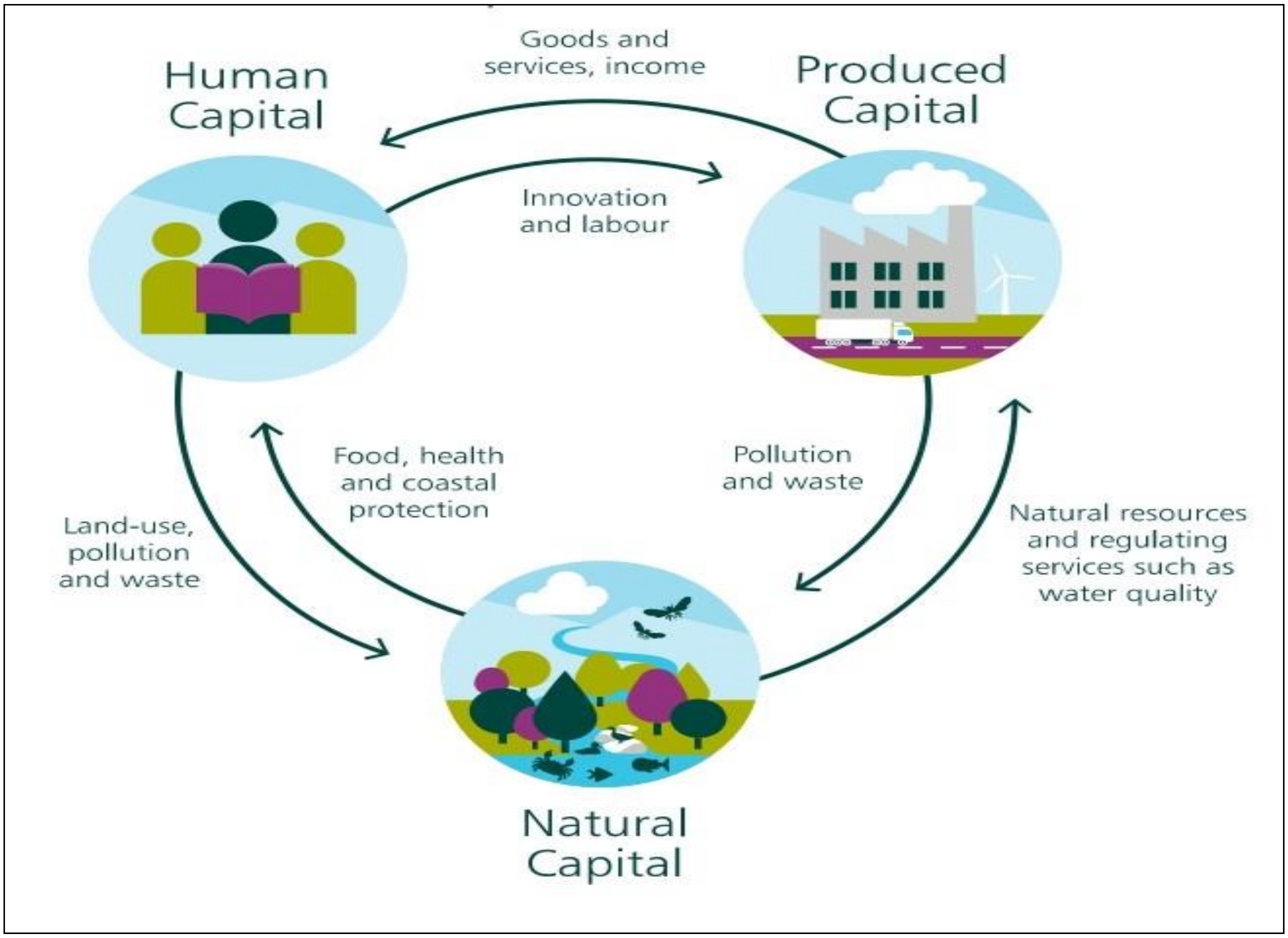
Introduction

1.1 Background and Motivation of the Study

Capital plays a vital role in economic progress of a country. Capital is broadly classified into three categories. These are physical capital, human capital and natural capital. Economists consider these assets because they are measurable. The idea of capital can be extended to knowledge, instutions, culture, and religion. But there are problem in measuring the value of these capitals. In the past, economists did not consider the natural assets as capital. It is difficult to estimate the natural resource stocks. Some of the natural resources are available for free. Hence market prices do not exist for these resources. Recently, scholars have devised the methods to value natural capital. Nevertheless these methods are under scrutiny and evolving. Dasgupta argues that it is better to consider the 'rough and ready figures' than to completely disregard the contribution of a set of capital provided by the nature. He, further, points out that the conventional macroeconomic theories which have shaped our economic understanding of the growth of the nation do not consider the human's dependency on nature (Dasgupta, 2021). It is very much important to acknowledge the contribution of nature in the economic progress of a country and enhancement of human well-being. While it is necessary to consider the contribution of different capitals, we should study the interaction between the capitals. Figure 1.1 shows the interconnection among human, physical, and natural capital. It depicts the flow of goods and services and bads between capitals. Understanding the intercation between the capitals is necessary for sustanable development policy fomulation.

In 2015, United Nations member states adopted the Agenda 2030 for Sustainble Development. There are 17 sustainable development goals (SDGs) , as shown in figure 1.2, involving 169 socio-economic targets to be achieved by 2030. The Brundtland Commission (1987) defines sustainable development as the 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

Figure 1.1 Interdependency of capitals



Source: Dasgupta, P. (2021), The Economics of Biodiversity: The Dasgupta Review. (London: HM Treasury)

Figure 1.2: Sustainable Development Goals

Source: United Nations official website: https://sdgs.un.org/goals

SDG 12 emphasizes on the responsible consumption and production. Within SDG 12, target 12.2 focuses on achieving the sustainable management and efficient use of natural resources. Natural resources or environmental assets are part of the productive base of the economy. It is essential to keep track of the stock of the natural resources existing in the country to manage it properly. This calls for the measurement of all the existing natural resources (NSO, 2013).

The growing thrust on sustainable development is getting reflected in national income accounting. Following the initiatives of the United Nations System of National Accounts (UNSNA), several countries have been taking initiatives for environmental accounting. A large body of literature is emerging on sustainable development which is emphasizing "natural resource stocks and environmental quality " and challenging the existing national accounts methodologies (Arrow et al 2010:1). Sustainable development as defined by the Brundtland Commission report in 1987 focuses on both the inter-generation and intergenerational human needs. The new paradigm has gone beyond human needs and changed the focus on human well-being. Several researchers have argued that human well-being should be the basis of economic evaluation (Dasgupta, 2012a, 2013; NSO 2013; Arrow et al 2010) where well-being is categorized as current and inter-generational.

Intergenerational well-being is dependent on the stocks of capital assets, considered as wealth, available in an economy. Wealth comprises produced capital, human capital, and natural capital (Dasgupta, 2012a, 2012b). Arrow et al (2010) define comprehensive wealth as the social value of the economy's productive base which comprises reproducible capital, human capital, natural capital, population, public knowledge, and formal and informal institutions. Sustainable development can be defined as non-declining wealth. Atkinson in 1993 proposed to use wealth as a yardstick of sustainable development (Dasgupta, 2012; Arrow et al 2010). Wealth/Well-being equivalence theorem, by Partha Dasgupta, says that well-being across generations increases if and only if the inclusive wealth of the nation increases. Inclusive wealth should be the standard of economic evaluation of nations (Dasgupta, 2021). For the measurement of the inclusive wealth, we need to value the environmental assets. In the conventional economic accounting process, contribution of these assets are missing (Padhan and Das, 2021).The stock of natural capital is a major component of national wealth. Our accounting framework must not miss this component while estimating the national accounts. For this purpose, environmental accounting is a necessary step that should not be avoided by any government.

The quest for wealth is of course not a new obsession and can be traced back to the eighteenth century. The title of the seminal book of Adam Smith 'An Inquiry into the Nature and Causes of Wealth of Nations' or popularly known as 'Wealth of Nations' indicates how wealth has been an integral part of the study even in the long past. How wealth was defined is a different issue, but how much crucial role it plays to understand the economy is a matter of concern. Given the importance of wealth to study the economy, several pertinent questions arise. Does the present income accounting system represent the real value of the wealth of the economy? If not, how are we evaluating the performance of the economy? How the present evaluation method accommodates different aspects of the economy, society, and the environment? If these aspects are not considered in the evaluation process, is it justified socially or environmentally?

1.2 Conventional GDP measurement

System of National Accounts prepared by the United Nations (UNSNA) provides the framework for measuring economic activities such as production, consumption, saving, and investment. Government authorities of all the countries follow this framework, for maintaining uniformity and comparability, to construct national accounts. National accounts reflect the state of the economy and are used to evaluate the performance of the economy. There are different national accounts like Gross Domestic Product, Net Domestic Product, National Income, Per Capita Income, etc. They are used to compare the economic performance of different economies. The most widely used one is the Gross Domestic Product (GDP). Hence, it is expected that these statistics should contain as much information as possible about the economy and society for better policy measures in a country.

The existing national accounting is subjected to “extreme narrowness” and does not collect some relevant information necessary for economic evaluation (NSO2013: 3). Current UNSNA has been criticized for its narrowness, for quite a long time, by the feminist economists and environmental economists. Feminist economists question the exclusion of unpaid works, which is mostly done by women, from the accounting system. Environmental economists raise concerns over the exclusion of environmental costs and benefits in the national accounts. The debate around the exclusion of environmental costs and benefits in accounting gave birth to the concept of green accounting or environmental accounting. In this research work we point out the negligence of the environmental dimension in the national accounts of India. It is very much important to understand the interaction between the economy and the environment. On the one hand, the environment provides inputs to the economy and contributes to economic growth. On the other hand, economic activities have certain environmental costs. The national accounts should reflect both aspects of the environment.

The approach to sustainability requires the measurement and publication of environmentally adjusted national income. Environmental accounting would help in understanding whether our economic behaviour is consistent with sustainability or not (Common and Sanyal, 1998). Present SNA is criticized for not capturing the negative effects of the production of non-renewable mineral resources. The depletion of such resources is not recorded in our accounting system. This lacuna in the accounting system leads to policies that result in non-sustainable economic growth (Santos and Zaratan 1997). It is essential to value natural capital to adjust economic aggregates. Calculation of green GDP helps in tracking the services of the environment and comparing the environmental conditions of different countries. Green GDP can be calculated in two ways: first, by deducting the cost of environmental pollution and resource depletion from the conventional GDP, second, by adding the value of ecosystem services to conventional GDP. Conventional GDP, here, means the GDP calculated by applying current SNA (Xu, Yu, and Yue, 2010). Green accounting would help in constructing policies related to environmental protection and resource utilization and maintenance (Ying et al, 2011). GDP plays an important role in the economic analysis but it is not sufficient for the measurement of welfare. Economic growth, inequality, and poverty should be measured by the wealth rather than GDP. Even Human Development Index suffers from the lack of capability to explain the intergenerational well-being as it does not capture the stocks of capitals existing in an economy (Dasgupta, 2013)

1.3 Environmental accounting framework at the Global level

The environmental or green accounting concept is not new. It has a history of nearly three decades. The need for integration of economic accounting with environmental aspects was very much realized after the World Commission on Environment and Development which is famously known as Brundtland Commission and United Nations Conference on Environment and Development, 1992 when Agenda 21 was also adopted. Brundtland Commission established a clear relationship between the economy, environment, and society. It called for the necessary steps to safeguard the intergenerational needs of society. Sustainable development is defined as economic development that does not compromise the fulfillment of the needs of future generations. Responding to these concerns for the environment, the 'Handbook of National Accounting: Integrated Environmental and Economic Accounting' was prepared in 1993. After this publication, several countries and researchers started working on the new accounting methods. Keeping in view the experiences in implementing the new methods, the Handbook was revised in 2003. The latest version of the handbook is the System of Environmental-Economic Accounting 2012—Central Framework that is published in 2014. It is also known as SEEA. This statistical framework for green accounting is consistent with SNA and acknowledged by many countries and government authorities (UN, 2014).

In addition to SEEA Central Framework 2012, UN has been working to improve the environmental accounting system and extend it to different areas. SEEA central framework takes into consideration the individual environmental assets and their relation to the economy. It does not consider the natural processes and interactions that happen between different natural resources. To fill this gap, SEEA Experimental Ecosystem Accounting was developed which tries to account for the ecosystem services provided by nature. Further, SEEA Agriculture, Forestry, and Fisheries were published in 2020 which attempts to integrate the trade-offs and dependencies between these sectors and the environment with national accounts. Similarly, an environmental accounting framework has been constructed for energy in the year 2019 (SEEA Energy); for water in 2012 to get the hydrological information and its relation to the economy (SEEA Water); for air emission in 2015 to collect information on emission released in the process of production, consumption, and accumulation. Draft of the SEEA Land Accounting was published in 2016. The land account is constructed to capture the changing shares of land use and land cover in a country. Handbook on the accounting of material flow was published in 2018 to account for the inputs provided by the environment, output given to the environment, and physical imports and exports. Most of these frameworks given by different authorities for environmental accounting are evolving and thus not conclusive. A country specific framework which would be consistent with SEEA is the need of the hours.

1.4 Classification of environmental assets

Assets are the items that store value and provide inputs to the production processes of the economy. These items can be artificial or naturally occurring through environmental processes. Environment has also components that carry values and provide inputs to the economy. These components are called environmental assets. Environmental assets are defined as "naturally occurring living and non-living components of the earth, together comprising the biophysical environment, which may provide benefits to humanity (UN 2014: 134). SEEA classifies the assets as follows: (see Table 1.1).

Table 1.1 Classification of environmental assets in the SEEA Central Framework

1. Mineral and energy resources
1.1 Oil resources
1.2 Natural gas resources
1.3 Coal and peat resources
1.4 Non-metallic mineral resources (excluding coal and peat resources)
1.5 Metallic mineral resources
2. Land
3. Soil resources
4.Timber resources
4.1 Cultivated timber resources
4.2 Natural timber resources
5. Aquatic resources
5.1 Cultivated aquatic resources
5.2 Natural aquatic resources
6. Other biological resources (excluding timber resources and aquatic resources)
7. Water resources
7.1 Surface water
7.2 Groundwater
7.3 Soil water

Source: United Nations (2014). *System of Environmental-Economic Accounting 2012_ Central Framework,* New York.

These resources contribute to the welfare of the human being. They provide services to living beings. All the services provided by these assets do not have market values. Non-market valuation approaches are adopted to value such resources. SEEA provides guidelines to construct asset accounts. Two types of asset accounts can be constructed: physical asset account and monetary asset account. A physical asset account gives information on stock and changes in the stock of a resource in terms of units like tonnes, kilogram, liter, etc. Reductions and additions to stock information are given in the physical account. A monetary asset account gives the monetary value of the resource. The valuation of environmental resources is part of the wealth accounting of an economy. Environmental asset accounting highlights the availability of resources both in physical and monetary terms. Hence, it is an essential step for sustainable development policy.

1.5 Objectives of the Study

Mineral resources are very important environmental assets of the country. They are considered as the building blocks for the Indian economy (CSO, 2018). They immensely contribute to the economic growth. Mining sector generates employment, output and foreign exchange. In developing countries it helps in reducing poverty. Minerals are raw materials for many industries such as cement, steel, etc. Minerals are one of the major source of energy in the world. Manufacturing industry is heavily dependent on mining industry. These contributions of minerals get highlighted in the national accounting system. But the total stock value or the wealth of the mineral resources is not calculated. Contribution to the GDP of the economy by the sector is measured as a flow. There are negative effects of the mining activities also. Due to mining air pollution, water pollution, forest degradation, soil erosion etc. occur. Local communities suffer from various health problems. In some cases of mining local people get displaced. While calculating the value of the contribution of mining sector to the economy these negative impacts are ignored. Hence, the real contribution remains unknown. It may lead to over estimation of the size of the mining sector. Mineral resources are finite and non-renewable in nature. Hence, judicious use of these resources is essential for sustainable development. For the formulation of sustainable development policy to govern the mining sector, firstly, we need to have a proper valuation of the existing stock of mineral resources in the country. Secondly, to get the value of real contribution of the sector we need to internalize the various costs accrued occurring due to mining. In a nutshell, environmental accounting of mineral resources is a necessary step for sustainable use of the minerals. In India, research on environmental accounting is scarce. A number of initiatives are being taken by the government and private organizations to develop green national accounts for different sub-sectors of the economy. I have discussed those studies in chapter-2 of the thesis. Keeping in mind the dearth of research in green national account of mining sector in India and the growing demand for research on sustainable development, this study aims to

(1) construct the physical and monetary asset accounts of mineral resources in India,

(2) adjust the conventional national account with the value of depletion cost and pollution cost from mining in India, and

(3) discuss the sustainability of mining sector in different states of India.

1.6 Methodology and Data

For the first objective, I have constructed the physical and monetary asset accounts of iron ore, manganese ore, and bauxite for the period between 1995 and 2015. Physical asset account provides the opening and closing stock of a particular mineral resource. This account reflects the volume of a particular mineral available at a point of time in physical terms. This account also highlights the additions and reductions in the stock of the resources. Trends in mineral extraction and reserve have been presented for three minerals. To construct physical asset account, I have used secondary data collected from various issues of Indian Minerals Yearbook published by Indian Bureau of Mines and from EPWRF. This study uses the Net Present Value (NPV) method to measure the value of the three minerals taken into consideration to construct the monetary asset account. The NPV method has three components: resource rent, discount rate, and life of mineral resources in years. Following residual value method I have calculated the resource rent. For this purpose, data are collected from Central Statistical Office, India and Reserve Bank of India. The life of mineral is nothing but the ratio of the stock of the resource in physical terms to the volume of annual extraction. These data are collected from Indian Minerals Yearbook and EPWRF. I have used 3per cent discount rate to get the NPV of the minerals. NPV of the resource is the wealth of the resource given in monetary terms.

To fulfill the second objective, I have calculated the environmentally adjusted gross value added (EGVA) for mining sector in India. Conventional GVA from mining and quarrying is adjusted with the depletion cost and pollution cost from mining in India for the period between 2004 and 2015. GVA data are collected from EPWRF and CSO, India. Depletion cost is measured using the El Serafy (1989) User's Cost approach. For this method also value of resource rent, discount rate, and life of the resource are required. To get these values, I have applied the same methods used for the objective 1. I have used Inter-governmental Panel on Climate Change (IPCC) method to calculate the volume of methane emission to the environment due to coal mining and handling. This method requires data on volume of coal production, methane emission factor, and conversion factor. I have collected the data of coal production both under-ground and surface from EPWRF and Indian Minerals Yearbook. Central Institute of Mining and Fuel Research, India (CIMFR) provides the emission factor to be applied for the coal mining and handling in India. Conversion factor is taken from the IPCC report, 2019. I convert the methane into carbon dioxide (CO_2) following the AR5 of IPCC (2019). CO_2 is valued according to the social cost of carbon measured by Ricke et al. (2018). Using purchasing power parity (PPP), I converted the US$ into Indian Rupee. PPP data from 2004 to 2015 are collected from OECD website. I have calculated the share (in percentage terms) of the cost of environmental pollution from coal mining in total value of coal output. It varies from 4.5 per cent to 3 per cent. I have used these percentage values to calculate the pollution cost for mining and quarrying sector, assuming that production of other minerals also release same percentage of emission to the environment. Applying these percentage value to the GVA of mining and quarrying, I get the value of pollution cost for the mining sector.

To assess the sustainability of mining sector in different states in India, I have calculated the genuine saving for the states. Genuine saving is calculated as follows.

Genuine Saving = Change in Capital Stock
- Depreciation of Physical Capital
- Value of Natural Resources Extracted
+ Expenditure on Health and Education

Change in capital stock data are collected from Reserve Bank of India website. Value of natural resources extracted is the value of mineral resources produced. I have collected the data on value of natural resources extracted and expenditure on health and education from EPWRF. A comparative study is provided for the states which are mineral rich and the states which are not. I have calculated the ratio of expenditure on health and education to the mining state domestic product (SDP) to see whether states are spending enough on human capital formation as compared to what they are getting from mining sector. I have presented the share of expenditure on health and education in gross state domestic product domestic (GSDP).

1.7 Chapter Outline of the Thesis

I have organized the thesis as follows. Three objectives have been studied in three separate chapters. Objective 1, 2, and 3 of the thesis are presented in chapter 4, 5, and 6 of the thesis respectively. Literature review, methodology and data sources are given separately for three different objectives.

Chapter 1 provides the introduction of the study. Section 1.1 presents the background and motivation of this research work. Section 1.2 provides a brief description on the conventional accounting system. Section 1.3 discusses the development of environmental framework at international level. Section 1.4 provides the classification of environmental assets by United Nations. Section 1.5 outlines the objectives of this research work. Section 1.6 discusses the methodology and data used for three objectives.

Chapter 2 traces the progress of environmental accounting in India. Research works on green accounting by individual scholars, private organizations and government of India are presented in this chapter. Chapter 3 provides a brief profile of mining sector in India. Contribution of mining industry to the output, employment, and trade is discussed. It covers the conventional economic accounting of the mining sector. In chapter 4, I have constructed the physical and monetary asset accounting of iron ore, manganese ore, and bauxite. Chapter 5 provides the value of environmental adjusted gross value added of the mining sector. In this chapter I have measured the depletion and pollution costs from coal mining and adjusted the conventional national account with these costs. Chapter 6 examines the sustainability of mining sector in Indian states. Genuine saving is calculated to assess the sustainability. I have compared the performance of states in terms of genuine saving. Chapter 7 summarizes the major findings of the study, limitations of the study and issues for further research.

1.8 Conclusion

The Brundtland Commission report (1987) on sustainable development called for necessary changes in the national account system by the United Nations as macroeconomic policies are guided by various national accounts such as GDP, Savings, Investments, etc. National accounts that incorporate the environmental aspects would help in sustainable development policy formulation and guide the extraction of non-renewable natural resources. Integration of environmental costs and benefits to the national accounts would give the real assessment of the economy and different sectors. My study on the integrated economic and environmental accounting of mineral resources in India therefore draws immense significance.

Chapter 2

Environmental Accounting in India

2.1 Introduction

Central Statistical Organisation, Government of India estimates the national account statistics such as GDP, NDP, Net Investment, Gross Saving, etc. for India and follows the methods of UNSNA. Three approaches can be adopted to estimate GDP: production, income, and expenditure approach. GDP is defined as the 'sum of gross value added (GVA) of all resident producer units of the economy during the reference period'. Gross value added is the value of output minus the value of input used in the production. Then to calculate Net Domestic Product (NDP), the value of Consumption of Fixed Capital is deducted from GDP (CSO, 2012).

GDP is a flow concept, whereas, wealth is a stock concept. To calculate the wealth of a country we need to estimate the monetary value of the total wealth of the country including the existing natural resources such as land, mineral reserves, water, etc. Environmental assets are parts of the wealth of an economy. Conventional national accounts do not value the existing stock of resources. A situation may arise when the GDP grows but the stock of natural resources depletes. This sort of GDP growth would be unsustainable. While calculating NDP we deduct the consumption of physical capital from GDP. But in the production process, natural capital also gets depleted. These depletions of natural capital are not adjusted in the estimation of NDP. Destruction of physical capital due to natural disasters also doesn't get an entry in NDP calculation (Das, Padhan, and Sahoo, 2021). Value of extraction of minerals, deforestation, pollution, etc should be deducted from GDP to get environmentally adjusted NDP. The value of ecological services should be included in GDP estimation. We are ignoring an important part i.e. environmental elements in our national accounts. This results in overestimation or underestimation of national income.

As cited in Kadekodi (2001), Parikh and Parikh (1997) give the formula for the calculation of Net National Product (NNP) as follows:

NNP = Value of consumption of normal goods and services
+ Value of production of nature collected
+ Value of environmental amenities
+ Value of leisure enjoyed
+ Value of net additions to production capital
+ Value of net additions to the natural capital stock
+ Value of additions to the stock of defensive capital

In the conventional NNP, only the depreciation of physical capital is subtracted from GNP. The above formula considers the value of environmental stocks and flows. It also takes into account the time as the capital as it accounts for the leisure enjoyed by people of a country. This formula gives the comprehensive notion of NNP.

As a step towards greening the national accounts of India, the National Statistical Organisation, Government of India prepared a report titled 'Green National Accounts in India: A Framework'under the chairpersonship of Sir Partha Dasgupta. The report was published in March 2013. Though the history of green accounting in India goes back to the 1990s, this report lays a proper foundation for green accounting in India. It provides conceptual clarity around green accounting and systematic guidelines to incorporate green elements into the conventional national accounting system of India. The central focus of this report is to convey how important it is to calculate wealth. The report also emphasizes the economic evaluation of economies based on wealth instead of the Gross Domestic Product or Human Development Index. It defines wealth as the value of reproducible capital, human capital, and natural capital existing in a country at a point in time. (NSO, 2013).

An increase in wealth depends upon the aggregate net investment. The wealth of an economy increases only when there is positive net investment prevailing in the economy. Net investment is nothing but the value of the rate of change in the stock of assets. A development process would be called sustainable only if the per capita aggregate net investment is positive. Per capita, aggregate net investment is defined as the social value of change in per capita stocks of assets. The report considers green GDP as a misnomer. To calculate the wealth of a country we have to measure the social value of the stocks of the different assets existing in the country. Social values are nothing but the shadow prices of resource stock. Shadow prices should be used in national accounts instead of market prices because market prices do not reflect or consider the externalities prevailing in the market. For some natural resources which are open to access the market prices could be zero even if they have positive social values in terms of providing positive environmental services. This consideration of the social value of assets in the report is significant because wealth calculation by multiplying stocks with market prices still misses the actual value of the resources as prices reflect the value of goods and services sans externalities.

In defining the relationship between wealth and sustainable development, the report makes two propositions:

a. “wealth and inter-generational well-being track one another: in any brief interval of time wealth increases if and only if intergenerational well-being increases”(NSO 2013: 39)
b. “an economy’s development is sustainable over any brief interval of time if and only if its wealth increases over the interval” (NSO 2013: 40)

Two more propositions are established to help in policy formulations. (i)A project would help to increase intergenerational well-being if it contributes to increase in wealth. (ii) Sustainability and policy analyses should be done based on the wealth of the economy. In a nutshell, the report suggests measuring the inclusive wealth of the economy to evaluate performance and sustainability. Inclusive wealth comprises reproducible capital (buildings, machinery, etc), human capital (knowledge, education, health, population, etc.), and natural capital (NSO, 2013).

Several studies have also attempted to measure green accounts for India. The study by Gundimeda et al (2006) has provided value to the bio-diversity functions of India's natural ecosystem. The authors have calculated the bio-prospecting values, ecotourism values, and non-use values of forests in India. The loss/gain of these values has been adjusted to Net State Domestic Product (NSDP) to get Environmentally Adjusted State Domestic Product (ESDP). Gundimeda et al (2005a) estimate the value of agricultural cropland and pastureland in India. They have assessed the costs of soil erosion, sedimentation, and land degradation. Then NSDP was adjusted by the monetary value of depletion and degradation to get ESDP. Gundimeda et al (2005b and 2007) have estimated to reflect the true value of forest resources in India's national and state accounts. The authors have taken into consideration four components of value creation in forests: timber production, carbon storage, fuel-wood usage, and the harvesting of non-timber forest products. They have further argued that there is a need to integrate natural resource accounting into the national accounting framework to generate appropriate signals for sustainable forest management and for the conservation of forest resources which are widely used by the poor in India, as well as being significant stores of national wealth. Kumar and et al (2006) have computed the economic value of ecological services of forests in India. Kumar et al (2007) have valued freshwater quality in India.

2.2 Studies Commissioned by the CSO

CSO, India has taken initiatives for natural resource accounting at the state level. It has commissioned several studies on green national accounts. The followings are some studies undertaken by different institutes.

Institute of Economic Growth, New Delhi (2006) submitted a report authored by M.N. Murty and S.C. Gulati which deals with the construction of physical and monetary accounts of air and water pollution in the states of Andhra Pradesh and Himachal Pradesh. The authors carried out the valuation of air pollution in the thermal power sector in the state of Andhra Pradesh using absolute shadow prices based on output distance function. The study estimated the pollutant loads such as SPM, NOx, SO2 generated by APGENCO and estimated the annual cost of reducing the pollution level in all the three pollutants at Rs. 534 million. The report recommended the pollution tax of Rs 2099, 201519, and 5554 for SPM, SO2, NO2 respectively. To get the value of green GSDP welfare losses due to air pollution are estimated using the general hedonic price model and adjusted to conventional GSDP. Damages from the air pollution in Hyderabad and Secunderabad were estimated at Rs. 6347 million which was 0.05per cent of state GSDP in 2003. The report also constructed physical and monetary asset accounts of air pollution from road transport in the state of Andhra Pradesh and Himachal Pradesh. The study estimated the abatement cost of air pollution from road transport at 2.13per cent and 2.16 per cent of GSDP of AP (2001-02) and HP (2002-2003) respectively. Firm-level environmental accounting was carried out for two firms from AP and HP by adjusting the value of industrial water pollution to net value-added. The study indicates the difficulties faced to estimate the pollution loads from agriculture sectors. (IEG, 2006)

A study by Madhu Verma and C.V. Kumar at Indian Institute of Forest Management, (2006) Bhopal provided the methodology and framework for forest and land natural resource accounting in Madhya Pradesh and Himachal Pradesh. Valuation of depletion, degradation of the existing stock of forest resources and land are conducted. The value of the opening stock of land increased from 1999-00 to 2000-2001 in HP was explained by the increase in farmland prices and opening stock. Degradation cost ranged from 1.82per cent to 1.69per cent of state GSDP of HP. In the case of MP also, the value of land increased from 1997-98 to 2001-02 due to an increase in farmland prices. The cost of degradation in MP ranged from 15.83 to 19.45 percent of the contribution of the agriculture and animal husbandry sector to state GSDP. After calculating the value of reductions and additions to forest stock in HP, the report found a net value changes worth of Rs. 3566 million in 2001-02. This value for MP was Rs. 1158.8 million in the year 2001-02(IIFM, 2006).

North East Hill University, Shillong(2008) carried out a study on the environmental accounting of land and forestry in the state of Meghalaya. NEHU calculated the monetary value of timber and fuel wood which was carried out by O.P. Singh and others. This study categorically pointed out the problem of data unavailability in the state of Meghalaya. The study used both primary and secondary data sources. The authors estimated the Environmentally Adjusted State Domestic Product (ESDP) by deducting the value of depletion of land resources at Rs. 41371.4 lakhs in 2001-02. ESDP after adjusting for depletion of forest resources was estimated at Rs. 13937.54 lakhs 2003-04 (NEHU, 2008).

Madras School of Economics, Chennai constructed the asset accounts of land and water resources in Tamil Nadu (NSO 2013). Report by Joyashree Roy at Jadavpur University (2008), Kolkata focused on natural resources accounting for the air and water in West Bengal. The cost borne by society due to water pollution in only one district of WB North 24 Paraganas was estimated at Rs 229 million. The study estimated the welfare gain by the population of Kolkata due to reduction of a unit of SPM at Rs. 54.05 million. And in the case of NO2, the value was estimated at Rs. 61.30 million (Jadavpur University, 2008).

The Energy and Resource Institute, New Delhi (2006) worked on the valuation of coal mineral resources and depletion of mineral stock in Madhya Pradesh and West Bengal. For the valuation of coal in both the states Net Present Value method was adopted as given by SEEA. User Cost method given by El Sarafy has been used to calculate the depletion cost of resource extraction. In MP the value of depletion of coal resource was 2.5per cent and 15per cent of mining sector state domestic product at 6per cent and 0per cent discount rate respectively in the year of 2001-02. For WB these values were 0.1per cent and 42per cent for the same year (TERI,2006).

A research team led by P.R. Panchamukhi in Centre for Multi-Disciplinary Development Research, Dharwad developed a framework for land and forest sectors in Karnataka. SEEA approach was adopted to construct the accounts. During 2002-03, the unrecorded value of NTFPs was 1.45 per cent of total SDP. The recreational value of the forest was found to be 0.02per cent of GSDP for the same year. Value of medicinal plants, Sacred groves, and watershed benefits of the forest was 0.01per cent, 0.001per cent, and 0.04per cent of State GSDP in 2002-03. The contribution of agriculture adjusted for land degradation was estimated at 19.5per cent to SDP which was 20.3per cent without adjustment (CMDR, 2008)

Most of these studies are area-specific and state-specific which should be expanded to all-India levels and all the sectors of the economy.

2.3 Recent Initiatives of CSO

The CSO has been publishing the environment statistics in different formats since 1997. Based on the *Framework for the Development of Environment Statistics (FDES)* (1984) the CSO published the Compendium of Environment Statistics in 2017. Although the report came out on annual basis, there was a discontinuity in 2004 and 2005. It also brought out a separate publication “Statistics Related to Climate Change” based on the Driving force-Pressure-State-Impact-Response Framework (DPSIR) in 2013 and 2015. With the revision of FDES in 2013, the CSO published EnviStats-India in 2018 in place of the earlier two reports (CSO, 2018). The United Nations Statistical Commission adopted the System of Environment-Economic Accounting (SEEA)-Central Framework for environmental-economic accounting at its 43rd session in 2012. Following this, an Expert Group was constituted in India under the Chairmanship of Prof. Sir Partha Dasgupta to chalk out the implementation plan for environmental accounting. The Expert Group listed out both the short term and long term activities to be undertaken. In pursuance of the recommendations of the Expert Group, the first publication on “Environmental Accounts" was published in 2018 providing the asset accounts of four main natural assets –land, forests, water, and minerals. Due to the growing demand for the environment and natural resources accounts the CSO for the first time released a supplement on environment accounts in September 2019 (CSO, 2019-1).The second publication in 2019 focused on the assessment of the quality of soil and water and valuation of the ecosystem services provided by cropland (CSO, 2019-2).

EnviStats India 2018 – A Supplement on Environment Accounts" was the first in the series of annual publications of NSO India to ensure that accounts depicting the status of the environment are made available in the public domain, to facilitate an understanding of the interdependence between the "factor nature" and the economy. In this publication, the asset accounts in physical terms of four natural resources – forest, land, minerals, and water were presented. In the subsequent publication released in 2019, some layers on the quality characteristics were added, namely, soil nutrient index and water quality accounts in respect of surface, ground, and seawater. Besides, to help understand the contribution of ecosystem services to the economy, values of two ecosystem services are compiled for all the States of India – cropland ecosystem services (provisioning of crops) and nature-based tourism. Recognizing the fact that the relationship between the environment and economy is multi-layered, the publication of 2020 includes not just updates of some of the previously published accounts, like those of Land Cover, but also includes some fresh ecosystem extent and condition accounts and estimates of ecosystem services

2.4 Challenges in greening the national accounts of India

Methods to estimate green accounts are evolving. Theoretically, it sounds good to expand the periphery of the traditional accounting system to environmental aspects to calculate the wealth of the economy and to have environmentally driven economic policies to achieve sustainable development. As we have discussed above, there is a framework given by the United Nations named the SEEA framework which sets the standard approaches for environmental accounting. This framework is constructed with the consultation of experts from different countries. It is accepted as a standard structure across the world. However, the difficulty in applying SEEA methods is not homogenous across nations, due to variations of the economic structure. Problems faced by different countries to use available natural resources are also specific. Developing countries are more dependent on the natural resources of different kinds to remove poverty and raising the living standard. This might be resulting in the creation of the complexity of environmental element entry to the accounting system.

The major problem faced by researchers and organizations in India who are working in the area of green accounting is data unavailability. Let's take the example of environmental accounting of mineral resources or subsoil resources. Mining has a significant contribution to the Indian economy, and especially for the low income states like Odisha, Chhattishgarh, and Jharkhand. The contribution comes in terms of share in the GDP/GSDP, revenues, employment generation, and creation of forwarding and backward linkages. But mining also brings negative environmental outcomes in terms of air pollution, deforestation, health problems to the community living nearby the mining area, etc (Das, 2014). These negative outcomes should be monetized and adjusted in national accounts. To our knowledge, these data are not available in the Indian context which makes it difficult to account for the environmental aspect of mining. Furthermore, we don't have systematic data on reserves of mineral resource stocks for each year. This brings complications in constructing a physical account that comprises an opening and closing stocks, discoveries, reclassifications, etc. This problem of unavailability of comprehensive data can be realized in other natural resources as well.

Another possible challenge that environmental national accounting may face is the lack of political will or indifference of national and state governments towards environmental concerns. Working towards greening national accounts requires large scale pan India data work like CSO’s data collection for GDP estimation. Independent research works by individual researchers or non-government organizations working in the limited area may facilitate the process of green national accounting method specific to India but not sufficient to estimate environmentally adjusted GDP. Hence, more proactive and comprehensive efforts by the national and state governments are necessary.

2.5 Conclusion

Individual researchers have started working on environmental accounting in India since the early 1990s. CSO has also attempted to work in this line since the 1990s. Though CSO, has initiated several studies on natural resource accounting, we are far away from measuring inclusive wealth and green GDP. It has been publishing Environmental Statistics on physical stocks of different natural resources. Valuation of all these resources is needed to calculate the wealth and to integrate the environmental aspects to economic accounting. India is also a part of the project by the UN called 'Natural Capital Accounting and Valuation of Ecosystem Services' (NCAVES) along with Brazil, China, Mexico, and South Africa. This can help the government of India significantly in the process of implementing SEEA. Indian Economy is divided into three sectors: agriculture, industry, and service sector. Human activities in these sectors have bearings on the environment which should be deducted from accounts and the contribution of the environment or nature to these sectors should be added to the accounts. This would help in the sectoral analysis of the economy with the environment being at the heart of policy formulation. The conventional national account system only considers the monetary value added from each sector to the economy. It neither accounts for the environmental stock nor the environmental pollution, degradation, and depletion of natural capital stock. This approach of accounting is not consistent with the idea of sustainable development. Hence, the Government of India should initiate the valuation of the stock of natural resources on the pan-India scale to get a sense of wealth existing in our country. Attempts should be made as early as possible to construct accounts for the ecosystem, energy, water, land, etc of the country following the methods, given iby the UN. Recommendations of the expert group led by Prof. Partha Dasgupta in NSO, 2013 report on green national accounts should be implemented soon. That would help in formulating the sustainable development policy.

Chapter 3

Mining Sector in India: A Profile

3.1 Introduction:

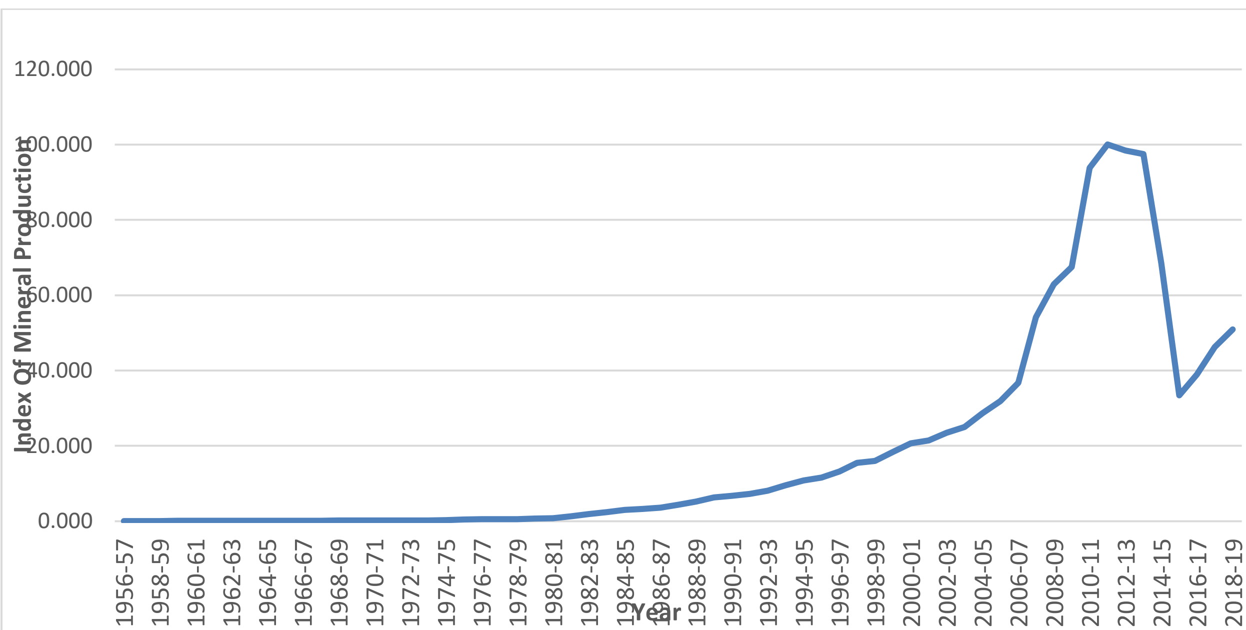
United Nations System of Environmental and Economic Accounting Central Framework classifies environmental assets into seven categories. These environmental assets are mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources, and water resources. Mineral resources are important environmental assets for the economy (UN, 2014). Natural capital is a chief component of wealth of the nation and productive base of the economy (Dasgupta, 2012, Arrow, et al., 2010, Padhan and Das, 2021). Mineral resources play vital role in economic growth. Minerals are building blocks of Indian economy (CSO, 2018). Mining, immensely, contribute to the process of industrialisation of the economy. It generates employment (Hota and Behera, 2016) output, and revenue (Das and Acharya, 2016) for the economy. Jobs and income created in mining industries have helped in alleviating poverty in local communities (Huang, Zhou and Ali, 2011). Export of minerals to the rest of the world helps maintaining a favourable trade balance and foreign exchange.

In developing countries, in recent past, 'governments of extractive economies' have tried to obtain benefits from mining industries to accelerate the development of the economy (Castano, et.al., 2019). Low and middle-income countries having abundant minerals have taken advantage of rising prices of minerals to foster economic growth (McMahon and Moreira, 2014).

3.2 Reserves and production of Minerals in India

India entirely lies in northern hemisphere. It is situated between latitudes 8° 4' and 37° 6' north, longitudes 68° 7' and 97° 25' east. It is 7th largest country in the world in terms of the geographical area. It has 32,87,263 sq.km. area. The country has geographical diversities having snow-covered Himalayan Mountains, long coast line, desert in the west and tropical rain forest in the south. India is a mineral rich country. 95 minerals are available in India out of which 4 are fuel, 10 are metallic, 23 are non-metallic and 55 are minor minerals (CSO, 2018). But it is not a mineral economy as per the definition of United Nations. UN considers an economy as mineral economy if the country 'generates at least 10 per cent of gross domestic product from mining and at least 40 per cent of their foreign exchange earnings come from mineral export' (UN, 1998).

Figure 3.1: Index of mineral production in India



Sources: Indian Minerals Yearbook of different years and EPWRF.

According to Envistat, "*mineral means a class of substances occurring in nature, definite chemical composition and usually, a characteristic crystal structure, but sometimes also includes rocks formed by these substances"(CSO, 2018, pg: 4.1).* Minerals are occurred in geological processes. Hence, they are finite and non-renewable and can't be reproduced in human time scale.

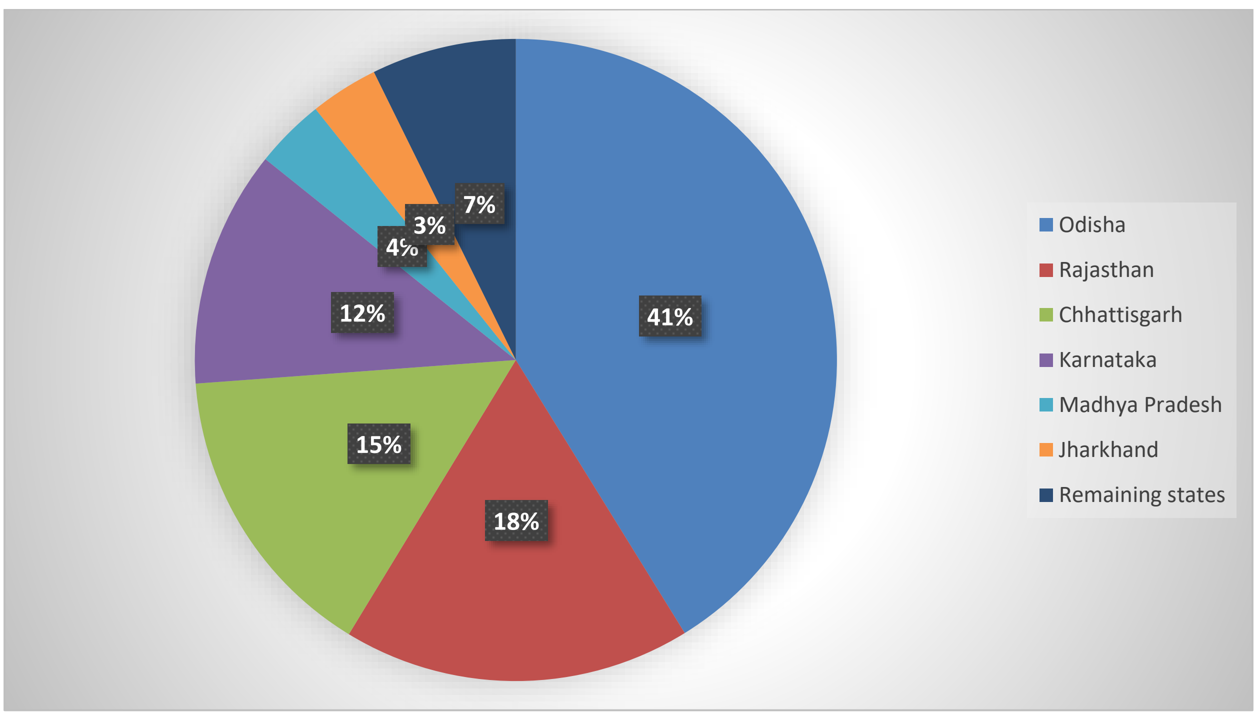
Table 3.1: Production of MCDR Minerals

Production of MCDR Minerals (in Rs. crore)			
	2018-19	2019-20	2020-21
Metallic Minerals			
BAUXITE	1717	1579	1649
CHROMITE	3584	3333	2341
COPPER CONCENTRATE	940	845	861
GOLD PRIMARY	524	643	544
IRON ORE	45184	48107	49160
LEAD CONCENTRATE	1632	1807	2042
MANGANESE ORE	2270	1942	1735
ZINC CONCENTRATE	5608	6023	6667
OTHER METALLIC	2584	2	2
Total Metallic Minerals	**64043**	**64281**	**65001**
Non-Metallic Minerals			
GARNET	157	0	2
LIMESHELL	3	2	0
LIMESTONE	8484	8312	8241
MAGNESITE	40	35	29
PHOSPHORITE	355	432	534
SILLIMANITE	56	4	3
WOLLASTONITE	17	12	10
OTHER NON-METALLIC	103	85	71
Total Non-Metallic Minerals	**9215**	**8882**	**8890**
Total Minerals	**73258**	**73163**	**73891**

Source: Production, Import and Export data, Ministry of Mines, Govt. of India(2021).

Figure 3.1 presents the index of mineral production in India. The year 2011-12 is taken as the base year for the construction of the index. Mineral production is nothing but the extraction of the mineral resources. Mineral production in India has increased steadily from 1957 to 2012 before declining from 2011-12 to 2015-16. After 2015-16 it started rising again. If we compare the value of mineral production in 1956-57 and 2017-18, there is more than thousand times increase in the production value (see figure 3.1). Table 3.1 highlights the production of metallic and non-metallic MCDR minerals. MCDR stands for Mineral Conservation and Development Rules. Value of iron ore production has the dominant share in metallic mineral production. In the non-metallic minerals category limestone has largest share in total value of production. Figure 3.2 shows the share of states in the value of mineral production in the year 2018-19. State of Odisha has the highest share of 41per cent followed by Rajasthan (18per cent) and Chhattisgarh (15per cent). Karnataka, Madhya Pradesh and Jharkhand have the share of 12, 4, and 3 percent respectively. Remaining states account for only 7per cent.

Figure 3.2: Share of states in value of Mineral Production in 2018-19



Source: National Mineral Scenario, Ministry of Mines, Govt. of India (2020).

3.3 Classification of mineral resources

Classification or definition of mineral stock is necessary to understand the physical accounts of the resources. Two mostly used approaches to classify mineral resources are McKelvey box and 'United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources' shortly known as UNFC classification.

McKelvey box categorizes the resources based on two criteria. One is uncertainty (geologic certainty) and other is economic viability. The degree of uncertainty is measured as proved, proven, and probable. Economic viability of extraction is categorized as economic, marginally economic and sub-economic. The McKelvey box distinguishes the reserves from total mineral resources. Reserve is defined as the part of the resource which can be economically extracted. As defined in CSO (2013), 'if a mineral resource is both known and economically profitable to exploit with existing technology and price, it is categorized as reserve'(p.160). Reserve is dependent on price, technological improvements and extraction cost. India followed the modified version of McKelvey box from 1981 to 2003. In 2003, India switched to UNFC classification.

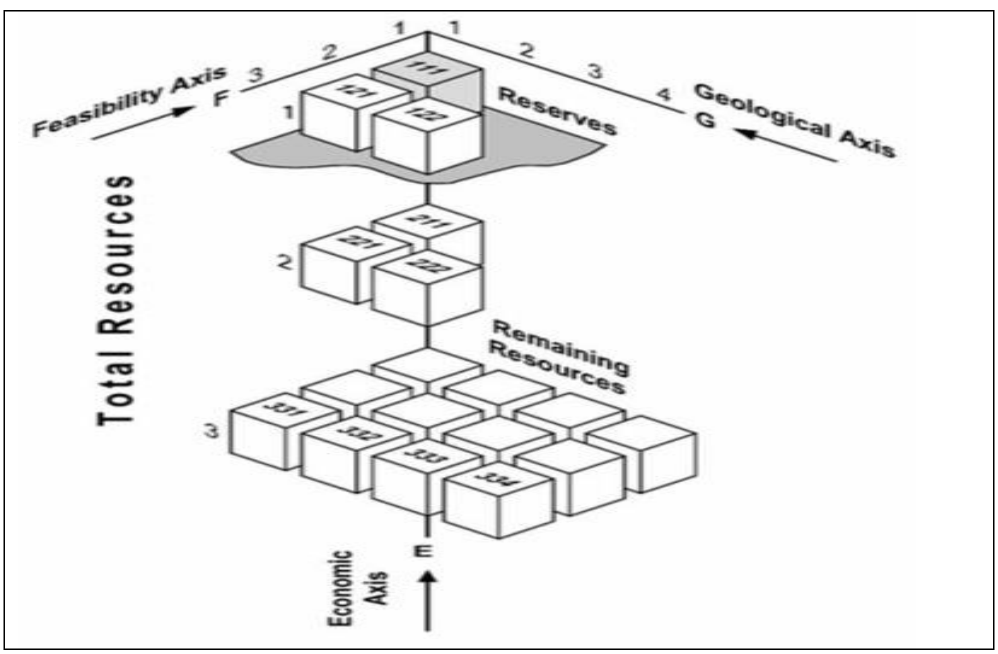
UNFC classification of mineral resources is more sophisticated than McKelvey box. To maintain uniformity and comparability across countries this classification is suggested by United Nations. It is a universally applicable system of classification. India has been following this classification since 2003. UNFC classification is three dimensional. In this system, resources are classified on the basis of three criteria such as economic viability, field project status and feasibility, and level of geological knowledge. Numeric codification is done on the basis of above three criteria. It follows three digit codification. The first digit denotes economic viability, second digit signifies feasibility and the third digit shows the geological axis.

Economic viability: Economic viability has three categorization with three codes such as 1, 2, and 3. In this categorization, 1 stands for the resources that are economically extractable; 2 represents the resources that are possibly economic depending upon the technology, environment and other factors; 3 is used to denote intrinsically economic mineral resources which are considered as remaining resources.

Feasibility assessment: In feasibility assessment, 1, 2, and 3 represents feasibility study and mining reporting, prefeasibility study, and geological study respectively.

Geological aspects: Geological axis has four codes where 1,2,3 and 4 represents detailed exploration, general exploration, prospecting, and reconnaissance respectively.

Picture 3.1. Three digit codification by UNFC



Source: United Nations Framework Classification for Fossil Energy and Mineral Resources https://unece.org/fileadmin/DAM/ie/se/pdfs/UNFC/UNFCemr.pdf .

The codes vary from the highest 111 to the lowest 334. In the code 111 for a particular mineral resource, the first 1 depicts that the resource is economically mineable; second 1 shows that the resource is at the stage of feasibility study and mining reporting; and third 1 denotes the detailed exploration of the resource. The following picture depicts the 3 dimensional codification and the distinction between reserves and remaining resources.

Total resources are classified as reserves and remaining resources. Reserve resources include proved (111) and probable (121+122) mineral resources. We can see that in reserve resources the first digit of all the three codes such as 111, 121 and 122 is 1. This means economic aspect is given more importance in deciding the reserve resources. Economic benefit is the deciding factor for the resources to be counted in reserve category. Highest categorization code 111 is used for proved mineral resources.

Table 3.2: Codification of Mineral resources in UNFC

1. Mineral Reserves	Code
-Proved mineral reserves	111
-Probable mineral reserves	121+122
2. Remaining Resources	Code
-Feasibility mineral resources	211
- Pre-feasibility mineral resources	221+222
-Measured mineral resources	331
-Indicated mineral resources	332
-Inferred mineral resources	333
-Reconnaissance mineral resources	334

Source: United Nations Framework Classification for Fossil Energy and Mineral Resources https://unece.org/fileadmin/DAM/ie/se/pdfs/UNFC/UNFCemr.pdf

3.4 Mineral resources in states of India

Table 3.3 : Mineral resources in states of India

States	Mineral Resources
Andhra Pradesh	Barytes, mica, dolomite, silica sand, quartz, diamond, ball clay, laterite, asbestos
Chhatisgarh	Coal, dolomite, iron ore
Goa	Iron ore, manganese ore, laterite, bauxite
Gujarat	Laterite, natural gas, agate, chalk, perlite, silica sand, lignite, bauxite, fireclay
Jharkhand	Bauxite, gold, kyanite, silver, coal
Karnataka	Iron ore, asbestos, granite, manganese ore, dunite, vanadium ore, tungsten ore, limestone, corundum
Madhya Pradesh	Copper ore, diamond, diaspore, rock phosphate, manganese ore, fireclay
Maharashtra	Corundum, China clay, bauxite, manganese ore, dolomite, flurite, shale, limestone, silica,
Odisha	Chromite, bauxite, graphite, manganese ore, iron ore, sillimanite, dolomite
Rajasthan	Jasper, zink, lead, asbestos, copper concentrate, ball clay, silver, marble
Tamil Nadu	Garnet, graphite, lignite, magnesite, dunite, rutile, bauxite
Assam	Petroleum and Natural Gas, Coal
Telangana	Coal, Manganese, Limestone, China Clay, Iron
West Bengal	Coal, China Clay, Granite

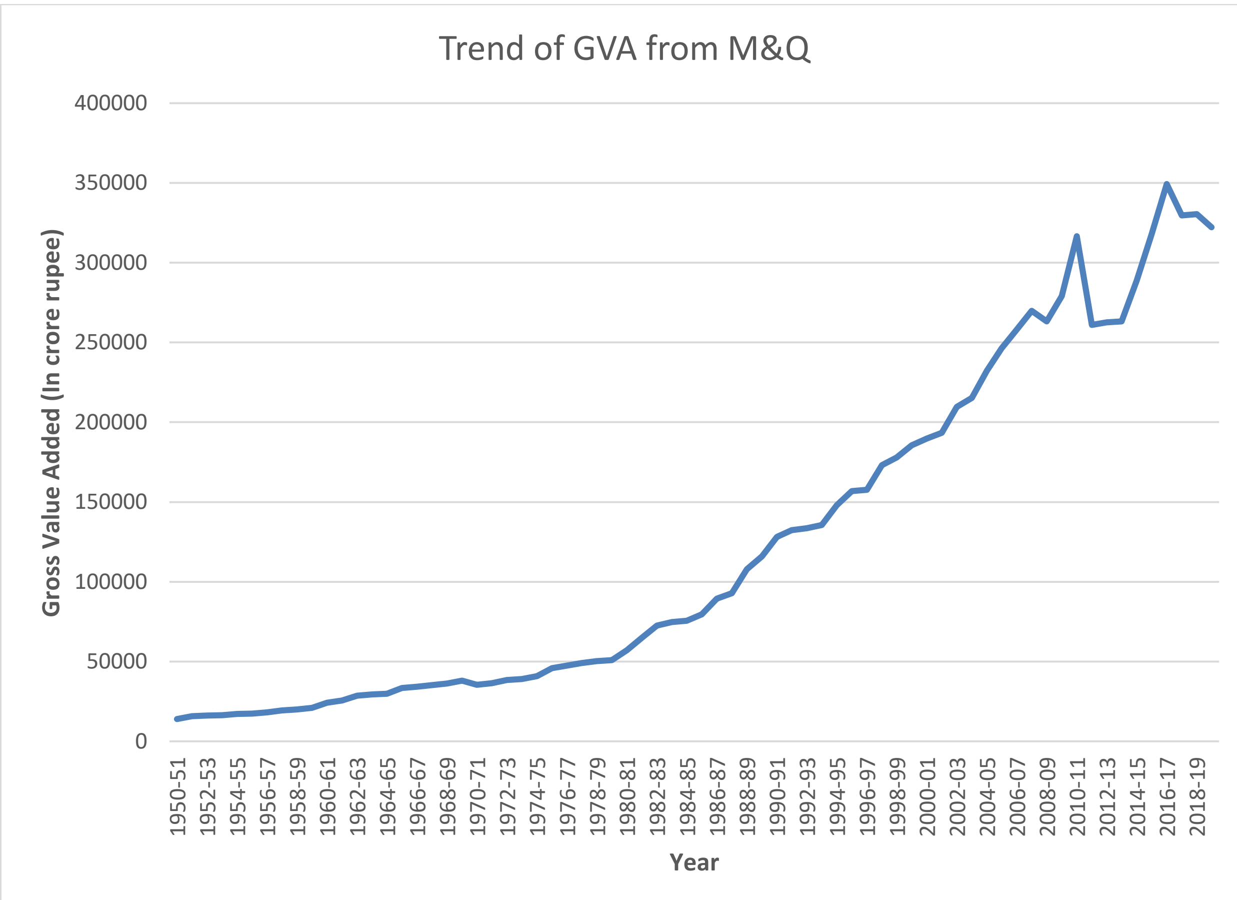
Sources:https://ibm.gov.in/writereaddata/files/09182018162439 and CSO (2018), EnviStats-India 2018, Central Statistics Office, Ministry of Statistics.

CSO (2018) divides India into four regions or belt. These regions are: the North-Eastern plateau region, the South-Western plateau region, the North-Western region and the Himalayan belt. The north-eastern plateau region includes the states of Jharkhand, Odisha, West Bengal and Chhatisgarh. In this region the major minerals available are manganese ore, iron ore, coal, mica and bauxite. The south-western belt covers the states of Karnataka, Goa, Tamil Nadu, and Kerala. Minerals such as bauxite, iron ore, manganese ore, limestone, monazite, thorium etc are found in this region. The north-western region covers the states of Gujarat and Rajasthan. Copper, zinc, granite, dolomite, etc. are available in this part of India. The Himalayan belt has minerals of copper, zinc, lead, cobalt, and tungsten. Mineral rich states in India are Odisha, Tamil Nadu, Rajasthan, Andhra Pradesh, Karnataka, Jharkhand (p. 4.7). Following table shows the occurrence of different minerals in the states of India.

3.5. Economic Contribution of Mining Sector to the Indian Economy

3.5.1 Output

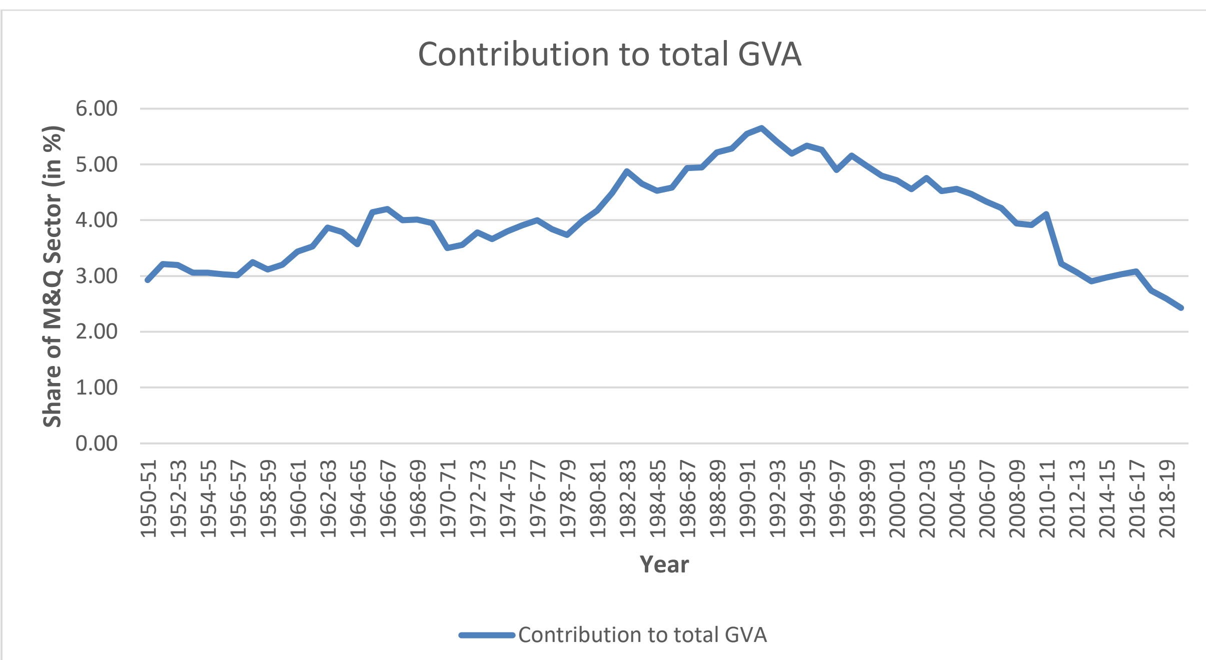
Figure 3.3: Trend of Gross Value Added from mining and quarrying (in crore rupee)



Sources: EPWRF and Indian Bureau of Mines.

The gross value added (GVA) from mining and quarrying has increased substantially from 1950-51 to 2019-20. Mining and quarrying GVA in 1950-51 was rupee 14032.75 crore which grew up to rupee 322116.24 crore in 2019-20. There is 23 times increase in the value of the GVA. Since 2016-17 the GVA has been declining. Before this, GVA has increased throughout since 1950-51 except for the years 2008-09 and 2011-12. We can see in figure 3.3 that there is a sharp decline in the value in the year of 2011-12. The trend also shows that the rate of increase till 1979-80 is less as compared to the increasing rate after that. After 1979-80 the trend line has become steeper. The 1991 economic policy of liberalisation, privatisation, and globalisation has brought significant change in the trend of GVA from mining and quarrying in terms of the absolute value. But if see the share of the mining and quarrying in the total GVA of the Indian economy, as depicted in Figure 3.4 , it has drastically declined from 1991-92. Because of new economic policy, the economy of India experienced a structural change. In the post-reform period there is major change in the contribution of different sectors to India's GDP.

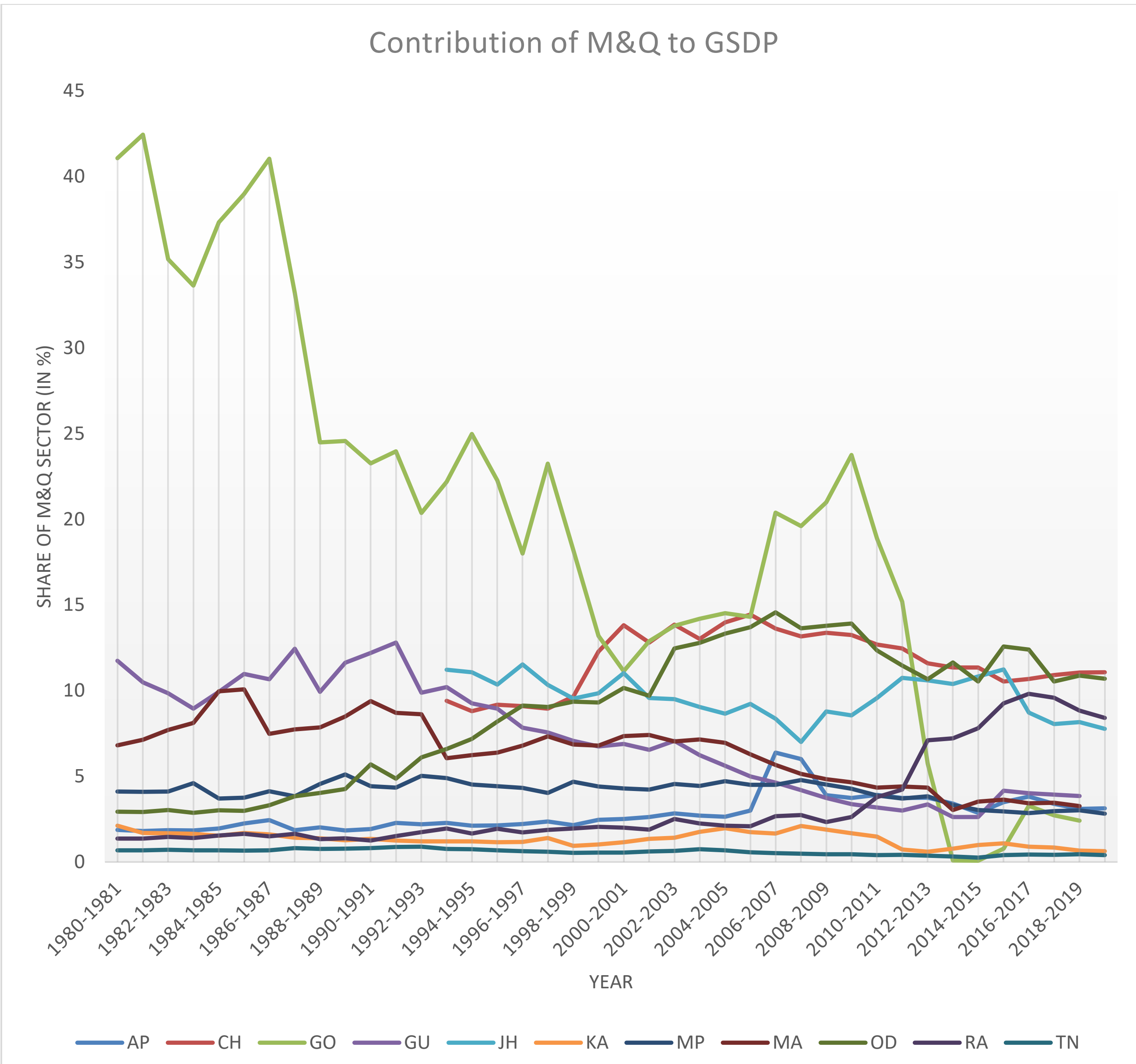
Figure 3.4: Contribution of M&Q sector to total GVA (In per cent)



Sources: Central Statistical Office and EPWRF.

In 1950-51, the contribution of M&Q sector to total GVA was 3.21 per cent which increased to the highest level of 5.65 per cent in the year of 1991-92. Since then the share of M&Q in GVA has been declining. In 2019-20 the share of M&Q in India's GVA had declined to 2.43 percent which is less than the contribution in the year 1950-51 (see figure 3.4).

Figure 3.5: Contribution of M&Q sector to state GSDP (In per cent)



Sources: EPWRF

Figure 3.5 shows the trend in the contribution of M&Q sector to the GSDP in the mineral rich states of the country. Mineral rich states in India are Andhra Pradesh, Chhattisgarh, Goa, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, and Tamil Nadu. We can observe from the trend that almost all the states have shown stability in the share of M&Q to GSDP except the states of Goa, Gujarat, and Odisha. This means if we compare the contribution in terms percentage to GSDP between1980-81 and 2019-20 in all the states except Goa, Gujarat and Odisha, we don't see any drastic difference. The graphs are also smooth. Whereas for Goa, Gujarat, and Odisha the change is so evident. During 1980-81, the share of M&Q to Goa's GSDP was 41.06per cent. It has come down to 2.41per cent in 2018-19. There is a decline of 38.65 percentage point. Till 2011-12 it has managed to maintain the contribution of more than 10per cent. In the case of Gujarat also the contribution has declined. In 1980-81 the M&Q sector's share was 11.74 per cent. It reached its highest level during 1991-92 that is 12.19per cent. Then throughout the period it shows declining trend and reached the lowest of 2.63per cent in 2014-15. During 1980-81, M&Q sector contributed 2.93per cent to GSDP. This has increased to 10.69per cent in 2019-20. This is a phenomenal increase of 7.76 percentage point. No other state has shown this level of increase in the share of the sector. During 2000-01 it reached the 10per cent mark. Since then, it has always been more than 10per cent in the case of Odisha. In the latest year of this study, out of 11 mineral rich states the contribution of M&Q sector has been more in the states of Odisha(10.69per cent), Rajasthan(8.41per cent), Chhattisgarh(11.07per cent), and Jharkhand (7.78per cent) as compare to other states.

Table 3.4: Share of Mining SDP in Industry Sector (per cent)

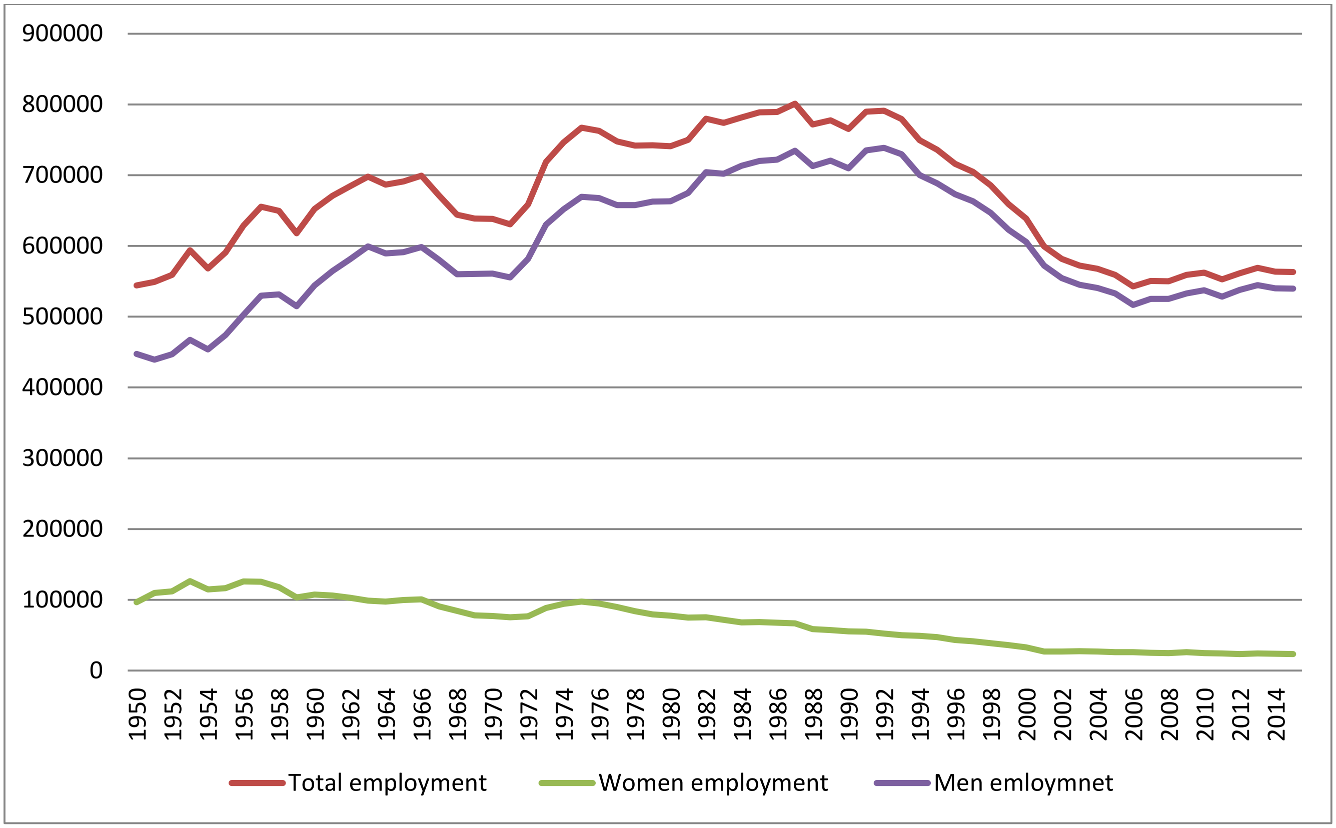
Year	AP	CH	GO	GU	JH	KA	MP	MA	OD	RA	TN
1980-1981	9.39	-	73.42	41.57	-	9.46	22.80	17.73	11.29	6.97	1.77
1981-1982	9.18	-	80.48	39.82	-	8.27	23.13	19.51	12.52	7.11	1.89
1982-1983	8.97	-	59.46	34.03	-	7.60	22.78	20.98	11.82	7.60	1.84
1983-1984	9.02	-	59.98	29.42	-	7.34	26.01	21.74	11.59	7.42	1.80
1984-1985	8.80	-	68.54	34.71	-	7.05	21.29	26.74	10.80	8.18	1.80
1985-1986	10.10	-	75.75	33.08	-	7.30	22.02	25.96	11.77	7.77	1.82
1986-1987	10.50	-	73.01	31.35	-	7.46	23.07	18.38	12.34	6.97	1.90
1987-1988	8.23	-	68.39	32.40	-	6.26	20.54	20.22	13.33	6.69	2.32
1988-1989	9.26	-	46.10	31.08	-	5.79	23.32	20.33	12.48	6.89	1.93
1989-1990	8.28	-	46.03	36.26	-	5.24	23.73	22.51	14.23	6.86	2.18
1990-1991	7.71	-	40.40	34.96	-	5.37	20.81	24.27	16.02	5.96	2.10
1991-1992	8.97	-	39.75	37.62	-	5.12	21.29	22.50	14.60	6.83	2.52
1992-1993	8.85	-	31.64	27.28	-	4.98	23.25	23.59	17.39	7.99	2.53
1993-1994	8.93	26.36	35.94	27.11	19.64	5.09	23.00	16.79	19.96	8.02	2.17
1994-1995	7.78	25.72	43.60	25.36	19.75	4.96	19.56	17.32	20.41	6.74	2.06
1995-1996	7.81	26.00	40.18	22.71	18.03	4.72	18.92	17.12	22.90	7.49	1.79
1996-1997	8.30	25.80	32.03	20.50	21.05	4.82	18.91	18.25	26.13	7.36	1.69
1997-1998	8.15	21.78	39.77	20.20	16.30	5.35	17.28	18.60	27.03	7.35	1.72
1998-1999	7.87	24.09	27.97	18.76	15.42	3.44	19.18	18.74	26.52	7.67	1.62
1999-2000	8.96	32.05	19.46	16.56	16.57	4.15	16.38	19.20	24.63	7.10	1.56
2000-2001	9.60	34.15	15.09	17.50	21.79	4.64	14.99	22.27	27.48	7.00	1.55
2001-2002	9.98	35.01	17.10	17.97	20.89	5.06	15.62	23.51	29.08	7.19	1.91
2002-2003	10.27	33.12	18.28	18.22	17.66	5.06	16.33	22.09	34.34	8.09	1.86
2003-2004	10.07	32.14	18.83	16.46	16.51	6.11	16.83	22.08	34.77	8.38	2.13
2004-2005	9.50	30.96	19.37	14.33	15.85	7.10	17.11	21.57	32.13	7.26	1.94
2005-2006	10.66	34.30	19.55	12.78	18.65	6.40	16.48	18.56	34.03	7.05	1.62
2006-2007	21.19	28.92	26.77	11.77	18.43	5.75	15.39	16.44	33.63	8.56	1.49
2007-2008	19.63	28.26	26.15	10.68	13.87	7.38	16.15	14.83	29.76	8.97	1.45
2008-2009	13.06	27.29	28.72	9.50	20.26	6.78	14.42	14.49	30.81	7.82	1.46
2009-2010	12.90	28.75	32.40	7.89	20.36	6.20	13.98	14.27	33.38	8.41	1.32
2010-2011	14.03	29.72	27.48	7.93	21.74	5.51	12.67	13.02	29.59	13.32	1.18
2011-2012	12.57	28.08	25.70	7.65	25.65	2.77	12.46	13.78	27.59	13.51	1.28
2012-2013	14.67	26.25	11.21	8.01	24.81	2.38	14.26	13.67	27.29	23.68	1.07
2013-2014	13.97	24.47	0.24	6.58	25.11	3.14	12.75	9.90	28.01	25.52	1.02
2014-2015	11.44	25.30	0.15	6.28	27.08	4.07	11.75	11.33	27.73	26.97	0.84
2015-2016	14.04	23.63	1.50	9.44	30.16	4.34	10.79	11.53	31.22	29.59	1.26
2016-2017	14.81	24.61	5.96	9.19	23.79	3.51	11.25	11.22	29.62	31.42	1.30
2017-2018	13.75	24.45	5.20	9.06	21.84	3.27	12.18	11.22	25.02	30.54	1.27
2018-2019	13.49	25.06	0.19	8.31	22.14	2.88	12.10	11.04	26.49	10.62	1.31
2019-2020	12.15	23.41	-	-	21.34	2.94	10.03	-	24.70	8.62	1.03

Sources: EPWRF

Table 3.4 presents the share of mining and quarrying SDP in industry sector of the states. Contribution of M&Q sector to industry sector has increased in Andhra Pradesh, Jharkhand, Odisha, and Rajasthan. Major increase has happened in the case of Odisha. In 1980-81, contribution was 11per cent which went up to 25per cent in 2019-20. Goa has shown a drastic decline. During 1980-81 it was 73 per cent which went down to 5 per cent in 2017-18. There is 68 percentage point decline in the contribution to industry sector. Tamil Nadu has been more consistent as compared to other states. The share of M&Q sector has varied from 1 per cent to 3per cent in the state. Major chunk of the value of industry sector in the states of Odisha, Chhattisgarh, and Jharkhand come from M&Q industry which is 25per cent, 23per cent and 21per cent respectively. In these states industry sector is more dependent on mining and quarrying. All the states given in table 3.3 have experienced positive growth in industry sector. But dependency on mining for the growth of industry sector of a few states have declined. Share of other sub-sectors must have increased in this period.

3.5.2 Employment

Figure 3.6: Trend of average daily employment in Mining and Quarrying



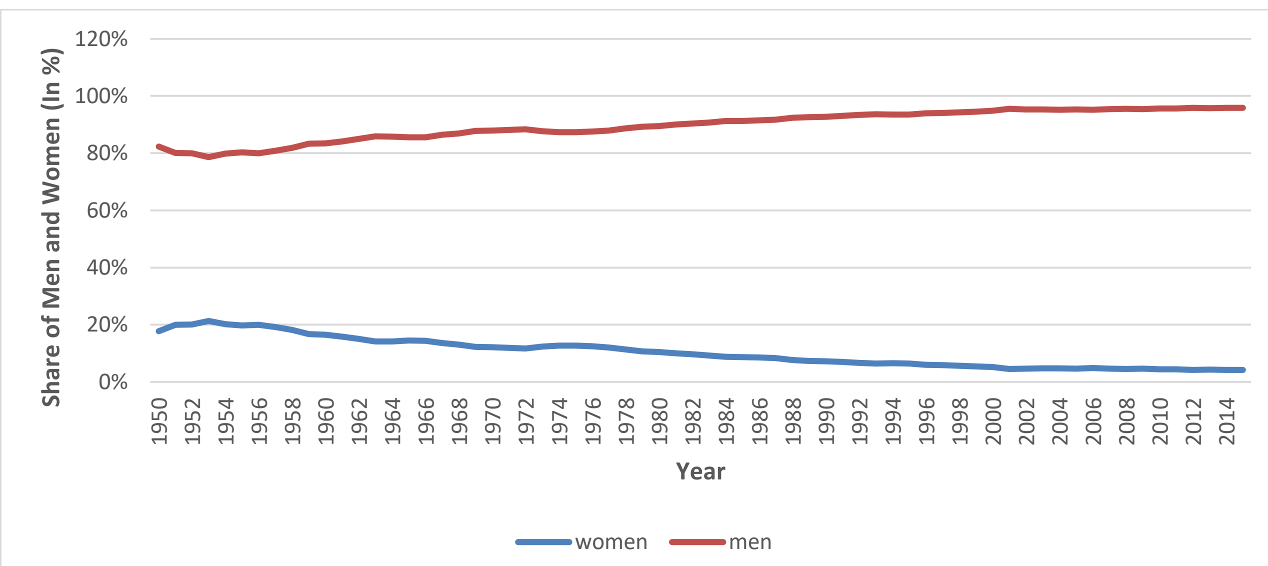
Sources: Indian Minerals Yearbook and EPWRF

Figure 3.6 shows the trend in average daily employment in mining sector in India. After 1992 there is a sharp decline in the total number of people employed in the sector. This could be because of mechanization of the process of mining. Earlier the mineral production used to be labour intensive. Introduction of machine in the production, loading, have pushed workers out of the mining job. Total employment in 2015 has declined to the level of 1954. Total employment and male employment have shown similar trend. Though the male employment has increased from 4,47,600 in 1950 to 7,38,424 in 1992 to reach its peak, there is drastic decline in the male employment afterwards. During initial period it has rising trend. But female employment has always shown a declining trend .The gap between the total employment and men employment gives the women employment. The gap is shrinking throughout the period. There is huge gap between the men and women employment. Employment in mining sector has always been heavily male dominating.

Figure 3.7 depicts that more than 80per cent of the workers are men. The share of women in the workforce in mining has declined from 18per cent in 1950 to 4per cent in 2015. The share of women employment exceeded 20per cent only during the period of 1951 to 1956. New economic policies of 1991 has not benefited women employment in the sector. The declining trend of women employment continues even after 1991.

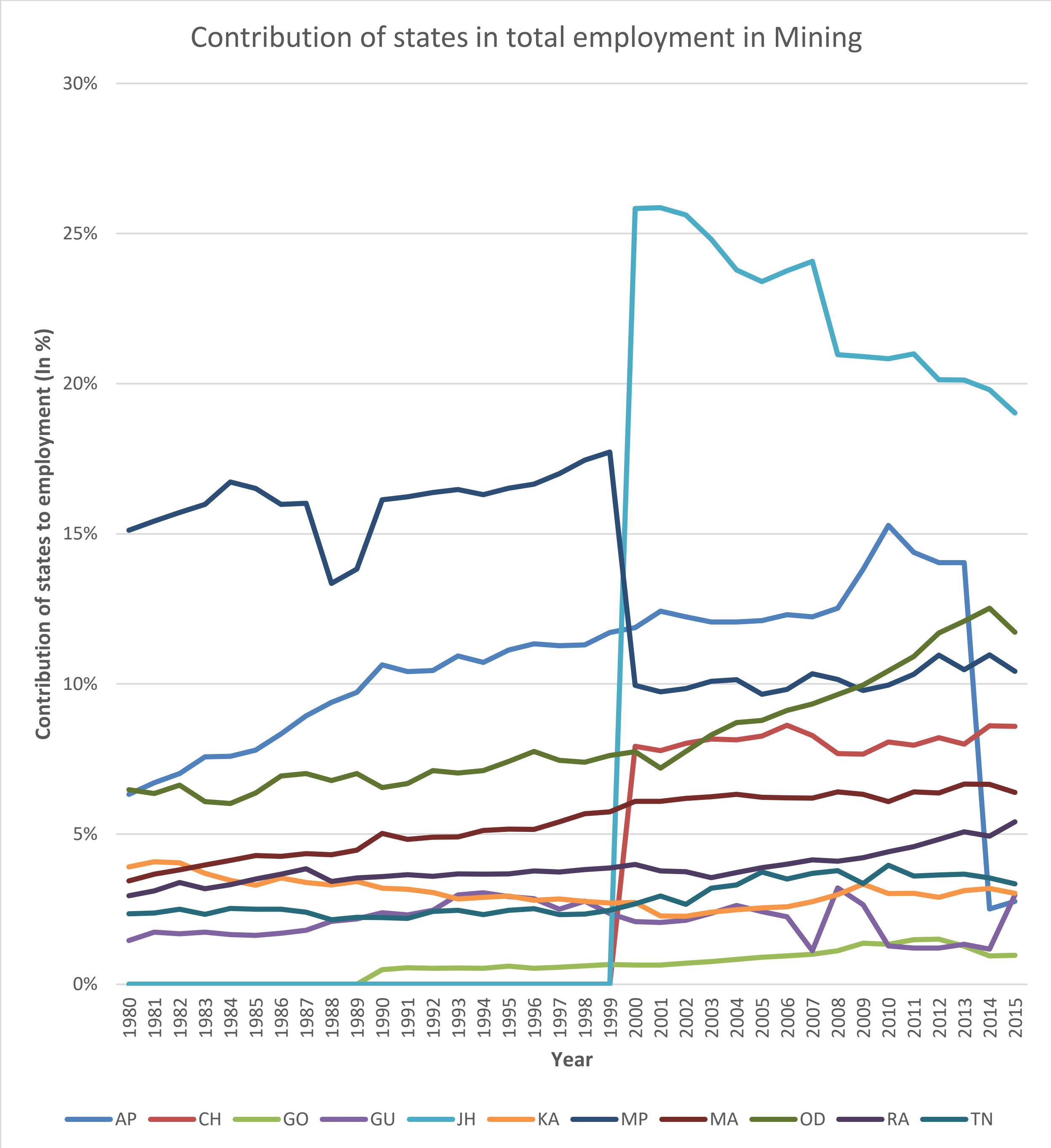
Among the mineral rich states Jharkhand, Odisha, Andhra Pradesh, Madhya Pradesh and Chhattisgarh have been contributing more to the total employment in the mining sector. In the year 2015, Jharkhand, Odisha, Madhya Pradesh and Chhattisgarh had 19per cent, 12per cent, 10per cent and 9per cent respectively in the total average daily employment M&Q sector of India. These four states have contributed 50per cent to the employment in mining. As compared to 1980, there is an increase in the employment in 2015 in the states of Odisha, Rajasthan, and Maharashtra (see table 3.5 and Figure 3.8).

Figure 3.7: Share of men and women in total employment in mining and quarrying sector (In per cent)



Source : EPWRF

Figure 3.8: Contribution of states to employment in Mining sector in India



Source: EPWRF

Table 3.5: Average Daily Employment (in thousand)

	All-India	AP	CH	GO	GU	JH	KA	MP	MA	OD	RA	TN
1980	750.7	47.5	-	-	10.9	-	29.3	113.5	25.8	48.6	22.1	17.6
1981	750	50.3	-	-	13	-	30.6	115.7	27.5	47.6	23.3	17.8
1982	779.6	54.7	-	-	13.1	-	31.5	122.5	29.7	51.7	26.4	19.5
1983	774	58.6	-	-	13.4	-	28.6	123.7	30.7	47.1	24.6	18
1984	781.4	59.3	-	-	12.9	-	27	130.7	32.2	47	25.9	19.7
1985	788.7	61.5	-	-	12.8	-	26	130.2	33.8	50.2	27.6	19.7
1986	789.3	65.8	-	-	13.4	-	27.9	126.1	33.6	54.7	28.9	19.7
1987	801.2	71.6	-	-	14.4	-	27.1	128.3	34.8	56.2	30.8	19.2
1988	777.5	73	-	--	16.3	-	25.7	103.8	33.5	52.7	26.6	16.7
1989	750.9	73	-	-	16.3	-	25.7	103.8	33.5	52.7	26.6	16.7
1990	765.4	81.4	-	3.7	18.2	-	24.5	123.5	38.4	50.1	27.4	17
1991	789.9	82.2	-	4.3	18.2	-	25	128.2	38.1	52.8	28.8	17.3
1992	792.5	82.8	-	4.2	19.5	-	24.2	129.8	38.8	56.4	28.5	19.2
1993	779.4	85.2	-	4.2	23.2	-	22.1	128.4	38.2	54.8	28.6	19.2
1994	749.5	80.3	-	4	22.8	-	21.7	122.2	38.4	53.3	27.5	17.4
1995	735.7	81.9	--	4.4	21.5	-	21.6	121.5	38	54.6	27	18.1
1996	716.2	81.2	-	3.8	20.4	-	20	119.3	36.9	55.5	27	18
1997	704.5	79.4	-	4	17.6	-	20	119.8	38.1	52.5	26.3	16.3
1998	685.7	77.5	-	4.2	19	-	18.9	119.7	38.9	50.7	26.2	16
1999	659	77.2	-	4.3	15.5	-	17.8	116.8	37.8	50.2	25.5	16.2
2000	639	75.9	50.6	4.1	13.3	165.1	17.4	63.6	38.9	49.5	25.5	17.1
2001	599	74.4	46.6	3.8	12.3	154.9	13.6	58.3	36.5	43.1	22.6	17.6
2002	582	71.2	46.7	4.1	12.4	149.1	13.2	57.3	36	45.1	21.8	15.5
2003	572	69	46.7	4.3	13.5	141.9	13.7	57.7	35.7	47.5	20.3	18.3
2004	568	68.5	46.2	4.7	14.9	135.1	14.1	57.6	35.9	49.5	21.1	18.8
2005	559	67.7	46.2	5	13.5	130.8	14.2	54	34.8	49.1	21.7	20.9
2006	543	66.8	46.8	5.1	12.2	129	14	53.3	33.7	49.5	21.7	19
2007	531.2	65	44	5.3	5.9	127.9	14.6	54.9	32.9	49.6	22	19.6

	All-India	AP	CH	GO	GU	JH	KA	MP	MA	OD	RA	TN
2008	549.5	68.8	42.2	6.1	17.6	115.2	16.4	55.8	35.2	53	22.5	20.8
2009	558.26	77.1	42.78	7.6	14.8	116.7	18.6	54.6	35.3	55.6	23.5	18.7
2010	532.9	81.4	43	7.1	6.8	111	16.1	53.1	32.4	55.6	23.5	21.1
2011	538.8	77.5	42.9	8	6.5	113.1	16.3	55.6	34.5	58.8	24.7	19.4
2012	538.6	75.6	44.2	8.1	6.5	108.4	15.6	59	34.3	63	26	19.6
2013	543.3	76.3	43.437	6.884	7.2	109.306	16.935	56.899	36.214	65.69	27.56	19.917
2014	539	13.5	46.4	5.1	6.3	106.7	17.2	59.1	35.9	67.5	26.6	19.1
2015	562.36	15.5	48.3	5.4	16.7	107	17	58.6	35.9	65.9	30.4	18.8

Source: Indian Minerals Yearbook and EPWRF.

Note: AP: Andhra Pradesh, CH: Chhatishgarh, GO: Goa, GU: Gujarat, JH: Jharkhand, KA: Karnataka, MP: Madhya Pradesh, MA: Maharashtra, OD: Odisha, RA: Rajasthan, TN: Tamil Nadu.

If we see mineral-wise employment, coal mining has been the major source of employment followed by iron ore. Since 1992 the employment in coal sector has declined throughout till 2015 whereas employment in iron ore mining has declined for some years after 1992 before increasing from 2004. However the level of employment in iron ore mine is less in the year 2015 as compared to the year of 1965. There is a decline of 11per cent in employment (see table 3.6).

Table 3. 6 : Average Daily Employment (mineral wise) (in numbers)

Year	Bauxite	Coal	Iron Ore	Manganese Ore	Oil	Chromite
1965	3215	424509	58813	45113	5053	724
1966	3361	425488	60339	46983	6768	759
1967	3560	413790	55538	44789	8625	1120
1968	3412	395364	52235	37219	10347	1546
1969	3896	396362	48641	30966	10630	1957
1970	4614	388137	51751	29295	11604	3408
1971	4815	377851	52821	30371	13573	3446
1972	5059	405049	50130	29342	12590	4907
1973	4777	470215	47982	27473	11984	3564
1974	3741	499994	47154	25810	12369	4938
1975	3856	517596	53181	25708	13068	5710
1976	3987	506051	55737	27416	13825	6617
1977	3815	493094	53155	27830	13990	5485
1978	4509	491526	51518	26796	12779	4829
1979	4269	493227	46205	28401	14502	4512
1980	4832	493969	43878	26842	14489	5647
1981	4317	507471	44933	26534	14548	5345
1982	4686	523276	47244	28186	15404	5394
1983	4564	528879	43771	23218	19414	6678
1984	5156	542450	42520	18898	18955	7247
1985	5992	543169	43869	18464	24789	6824
1986	6469	535985	46594	17656	24872	8039
1987	6559	542314	48756	17551	25937	8841
1988	5506	530790	45962	17418	26629	8436
1989	5642	541100	44497	16061	25203	9500
1990	5261	542113	38067	17285	26967	9886
1991	4927	547235	40050	17866	35513	10569
1992	5718	544780	42031	18382	35744	10608
1993	6441	537923	39751	18548	33456	10526
1994	6115	515205	38546	18248	34323	9977
1995	6372	504814	39657	18085	34007	9408
1996	5811	497311	39195	18129	33448	9781
1997	5917	494658	38637	16074	28611	9133
1998	5744	482415	37290	15894	29532	9012
1999	5733	465920	36183	16468	25518	8018
2000	5387	449021	35293	16136	23442	6909

Year	Bauxite	Coal	Iron Ore	Manganese Ore	Oil	Chromite
2001	4562	428855	32305	13637	24481	6506
2002	4541	413467	33657	13729	22348	6920
2003	4929	405719	35823	13266	18592	6649
2004	6055	393514	38607	14569	19155	7543
2006	5000	373160	41565	13170	13932	6969
2007	5468	366659	41781	13387	19211	7408
2008	5645	356848	44828	13469	23574	8116
2010	6642	355731	47311	13871	29443	8648
2011	6759	352930	52657	15810	27347	8972
2012	7428	345302	55290	16459	22789	8572
2013	6902	343944	52933	17444	25971	10162
2014	6637	343548	50512	18842	24815	10549
2015	7766	328751	52062	22610	28471	10962

Source: Indian Minerals Yearbook and EPWRF

Table 3. 7: Employment Elasticity in mining and quarrying

Year	Growth rate of GVA from M&Q (per cent)	Growth rate of employment (per cent)	Employment Elasticity
1951-52	12.33	1.88	0.15
1952-53	2.31	6.19	2.68
1953-54	1.50	-4.31	-2.87
1954-55	4.28	3.94	0.92
1955-56	1.58	6.42	4.07
1956-57	5.09	4.25	0.84
1957-58	6.50	-0.90	-0.14
1958-59	3.12	-4.84	-1.55
1959-60	5.15	5.52	1.07
1960-61	14.97	2.90	0.19
1961-62	5.76	1.97	0.34
1962-63	11.87	2.03	0.17
1963-64	2.96	-1.62	-0.55
1964-65	1.44	0.64	0.45
1965-66	11.75	1.17	0.10
1966-67	2.36	-3.99	-1.69
1967-68	3.03	-4.03	-1.33
1968-69	2.83	-0.89	-0.32
1969-70	4.94	-0.05	-0.01
1970-71	-6.85	-1.17	0.17
1971-72	2.64	4.40	1.67
1972-73	5.91	9.17	1.55
1973-74	1.26	3.80	3.02
1974-75	4.96	2.78	0.56
1975-76	12.13	-0.56	-0.05
1976-77	3.55	-1.94	-0.55

Year	Growth rate of GVA from M&Q (per cent)	Growth rate of employment (per cent)	Employment Elasticity
1977-78	3.13	-0.81	-0.26
1978-79	2.71	0.05	0.02
1979-80	1.08	-0.20	-0.18
1980-81	12.19	1.23	0.10
1981-82	13.66	3.97	0.29
1982-83	11.89	-0.72	-0.06
1983-84	2.89	0.97	0.33
1984-85	1.17	0.92	0.79
1985-86	5.46	0.08	0.01
1986-87	12.25	1.50	0.12
1987-88	3.77	-3.69	-0.98
1988-89	16.17	0.77	0.05
1989-90	7.59	-1.56	-0.21
1990-91	10.46	3.20	0.31
1991-92	3.36	0.14	0.04
1992-93	0.92	-1.46	-1.59
1993-94	1.39	-3.84	-2.76
1994-95	9.29	-1.78	-0.19
1995-96	5.87	-2.71	-0.46
1996-97	0.55	-1.63	-2.93
1997-98	9.81	-2.68	-0.27
1998-99	2.83	-3.90	-1.38
1999-00	4.19	-3.06	-0.73
2000-01	2.31	-6.17	-2.67
2001-02	1.86	-2.91	-1.56
2002-03	8.42	-1.64	-0.20
2003-04	2.70	-0.77	-0.29
2004-05	7.91	-1.55	-0.20
2005-06	6.12	-2.88	-0.47
2006-07	4.69	1.36	0.29
2007-08	4.61	-0.08	-0.02
2008-09	-2.50	1.64	-0.66
2009-10	6.02	0.61	0.10
2010-11	13.47	-1.72	-0.13
2011-12	-17.53	1.57	-0.09
2012-13	0.60	1.39	2.31
2013-14	0.19	-0.97	-5.10
2014-15	9.72	-0.12	-0.01

Source: Author’s own calculation from the data of Central Statistical Office and EPWRF.

Table 3.7 provides the employment elasticity in mining industry. Employment elasticity indicates the proportionate change in the persons employed in the industry for proportionate change in the output produced. It is calculated as the ratio of growth rate of employment to the rate of growth of the output (Das and Acharya, 2016). In this study we have calculated the growth of GVA from mining and quarrying from 1951-52 to 2014-15. Growth rate has been positive for all most all the years except 2011-12, 2008-09, and 1970-71. The growth rate of employment has been negative for most of the years. Employment elasticity would be negative if any of the growth rate is negative. If we see the trend in growth rate of employment, the economy has faced a phase of negative growth since 1992. From 1992 to 2006, growth rate of employment is negative. Whereas for this period, growth rate of output has been positive for all the years. Growth of the mining sector has not contributed to the generation of employment in the economy during this period.

3.5.3 Trade

Export value of ores and minerals has increased substantially from 1956 to 2018. In the year 2017-18, the value of export was Rs. 1,99,120 crore. This accounts for 10.17per cent of the total merchandise export value of India. There is a decline of 0.5per cent of export value in the year 2017-18 compared to the value of previous year. Diamond has the maximum share of 81.37per cent in the total value of export of minerals followed by iron ore (4.77per cent) and granite (4.64per cent) in the year 2017-18. The value of import during 2017-18 was Rs. 10,28,501 crore. This is 34.27per cent of the total merchandise import value of the country. Import of petroleum accounted for 54.75per cent of the total minerals import value. Petroleum takes the largest share followed by diamond (18.49per cent) and coal (13.46per cent). Table 3.8 provides the trade balance in mineral sector in India. In most of the year since 1957, India has experienced negative trade balance. During initial period it used to have positive trade balance. The negative trade balance has been increasing (see figure 3.9). The share of import in GVA of mining and quarrying has gone up significantly. The percentage of trade balance in M&Q GVA has increased remarkably. For most of the years it is negative. Hence, not favourable to trade in minerals.

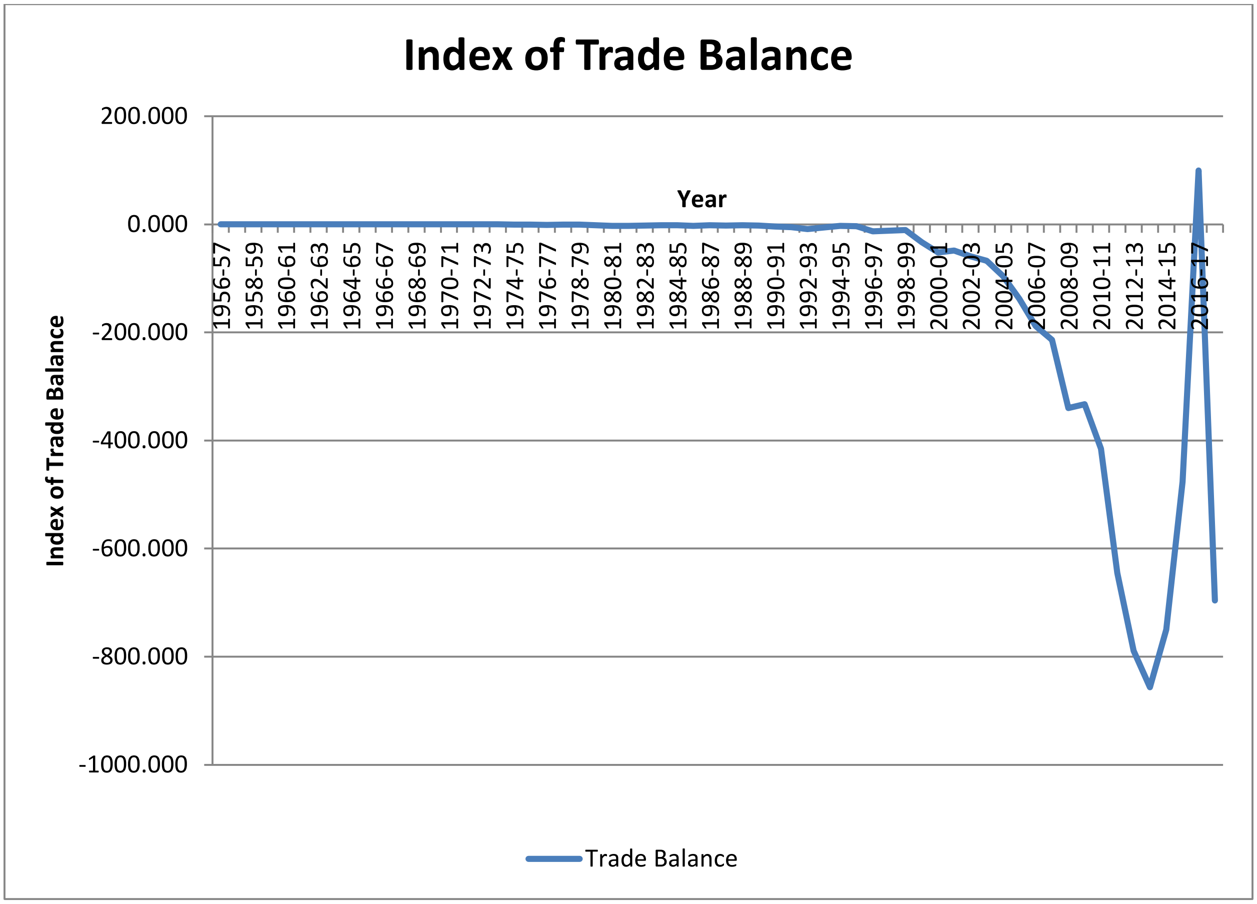
Table 3.8: Trade balance of mining sector

Year	Export (Rs. Crore)	Import (Rs. Crore)	Trade Balance (Rs. Crore)	Trade Balance as percentage of M&Q GVA	Import as percentage of M&Q GVA
1956-57	52.67	9.73	42.93	0.24	0.05
1957-58	64.14	9.41	54.73	0.28	0.05
1958-59	46.66	7.99	38.67	0.19	0.04
1959-60	58.08	10.17	47.91	0.23	0.05
1960-61	67.91	10.81	57.09	0.24	0.04
1961-62	66.00	11.34	54.66	0.21	0.04
1962-63	60.44	15.04	45.40	0.16	0.05
1963-64	69.49	15.84	53.66	0.18	0.05
1964-65	80.47	59.20	21.27	0.07	0.20
1965-66	80.47	60.85	19.62	0.06	0.18
1966-67	113.57	90.43	23.14	0.07	0.26
1967-68	138.97	145.75	-6.78	-0.02	0.41
1968-69	162.07	159.43	2.64	0.01	0.44
1969-70	171.44	158.91	12.53	0.03	0.42
1970-71	203.29	170.47	32.81	0.09	0.48
1971-72	189.83	210.29	-20.46	-0.06	0.58
1972-73	223.19	223.42	-0.23	0.00	0.58
1973-74	248.78	360.43	-111.66	-0.29	0.92
1974-75	312.88	1061.83	-748.95	-1.83	2.60
1975-76	407.99	1176.25	-768.26	-1.67	2.56
1976-77	581.77	1464.92	-883.14	-1.86	3.08
1977-78	871.10	1709.20	-838.11	-1.71	3.49
1978-79	1050.73	1863.49	-812.77	-1.62	3.70
1979-80	921.52	2805.39	-1883.88	-3.70	5.52
1980-81	1024.00	4027.22	-3003.22	-5.26	7.06
1981-82	1427.14	4447.81	-3020.67	-4.66	6.86
1982-83	2514.43	5142.43	-2628.01	-3.62	7.09
1983-84	2956.09	4999.65	-2043.56	-2.74	6.70
1984-85	3367.70	4950.42	-1582.72	-2.10	6.55
1985-86	2343.99	5489.40	-3145.41	-3.95	6.89
1986-87	2721.23	4275.89	-1554.66	-1.74	4.78
1987-88	3312.08	5724.05	-2411.97	-2.60	6.17
1988-89	5412.63	7081.54	-1668.91	-1.55	6.57
1989-90	6741.81	9660.39	-2918.58	-2.52	8.33

Year	Export (Rs. Crore)	Import (Rs. Crore)	Trade Balance (Rs. Crore)	Trade Balance as percentage of M&Q GVA	Import as percentage of M&Q GVA
1990-91	6659.44	11576.08	-4916.63	-3.84	9.04
1991-92	8342.61	14803.68	-6461.07	-4.88	11.18
1992-93	10210.52	20289.08	-10078.56	-7.54	15.18
1993-94	14266.48	21460.15	-7193.67	-5.31	15.84
1994-95	15831.83	19365.91	-3534.07	-2.39	13.08
1995-96	19819.86	23659.95	-3840.09	-2.45	15.09
1996-97	18956.17	34286.29	-15330.12	-9.73	21.75
1997-98	20642.84	34654.81	-14011.97	-8.10	20.02
1998-99	24621.75	37349.48	-12727.73	-7.15	20.99
1999-00	32751.74	71877.71	-39125.97	-21.10	38.76
2000-01	34410.54	96521.89	-62111.35	-32.74	50.87
2001-02	35136.16	92796.58	-57660.42	-29.84	48.02
2002-03	46618.27	117294.40	-70676.13	-33.73	55.98
2003-04	49925.81	130060.17	-80134.36	-37.24	60.44
2004-05	70468.46	184757.74	-114289.28	-49.22	79.56
2005-06	79789.98	243838.78	-164048.80	-66.57	98.95
2006-07	80930.74	305027.95	-224097.21	-86.87	118.24
2007-08	95022.49	349506.52	-254484.03	-94.30	129.51
2008-09	109296.45	514509.34	-405212.89	-153.99	195.53
2009-10	127831.14	524829.98	-396998.84	-142.31	188.13
2010-11	174370.40	669010.03	-494639.63	-156.27	211.36
2011-12	175309.50	944430.33	-769120.83	-294.64	361.80
2012-13	160101.26	1100800.15	-940698.89	-358.21	419.18
2013-14	194783.52	1215826.80	-1021043.28	-388.07	462.10
2014-15	178019.41	1071732.80	-893713.39	-309.58	371.25
2015-16	170946.32	738788.94	-567842.62	-178.58	232.34
2016-17	200130.68	80944.51	119186.17	34.13	23.18
2017-18	199120.44	1028501.29	-829380.85	-251.62	312.03

Source: Indian Minerals Yearbook, Reserve Bank of India and EPWRF.

Figure 3.9: Index of Trade balance of minerals



Source: Indian Minerals Yearbook, Reserve Bank of India and EPWRF.

Table 3.9 highlights the share of export in production of minerals in percentage. India exports less than 1per cent of its coal production. Most of the coal produced is used for internal consumption. It is essential input for steel production. 55per cent of the total primary commercial energy comes from coal. 72per cent of the power generated in the country is coal based. During 2019-20, 89per cent of total coal was used in power sector. Major share of the chromite, iron ore and manganese ore production was exported during 1970s and 1980s. As we can see in the table during 1969-70, 51per cent of iron ore, 81per cent of manganese ore and 49 per cent of chromite were exported. In the recent years it has declined drastically.

Table 3.9 Share of export in total production of some minerals (per cent)

Year	Bauxite	Chromite	Iron Ore	Manganese Ore	Coal
1969-70	11.61	49.27	51.13	81.28	0.37
1970-71	9.83	56.05	67.61	94.81	0.53
1971-72	3.55	47.73	56.41	67.50	0.37
1972-73	1.64	37.49	61.78	52.40	0.35
1973-74	2.20	81.10	59.85	46.37	0.63
1974-75	1.64	76.32	61.61	68.79	0.46
1975-76	1.12	74.10	54.61	50.30	0.45
1976-77	2.38	70.37	53.66	42.69	0.59
1977-78	2.81	24.55	50.62	23.77	0.64
1978-79	1.13	42.80	54.03	38.77	0.26
1979-80	2.33	68.66	62.14	35.39	0.09
1980-81	4.74	40.44	53.42	35.98	0.10
1981-82	6.79	42.64	56.93	36.06	0.10
1982-83	19.40	42.85	50.84	28.32	0.09
1983-84	6.02	28.72	57.95	28.00	0.04
1984-85	2.97	52.51	60.78	54.90	0.07
1985-86	1.74	42.86	69.92	39.87	0.13
1986-87	3.22	18.78	55.76	-	0.06
1987-88	5.24	30.11	58.58	-	0.08
1988-89	-	-	-	-	0.09
1989-90	4.92	23.33	66.16	26.33	0.11
1990-91	3.95	17.82	60.51	22.45	0.19
1991-92	-	-	-	-	0.06
1992-93	-	-	38.56	-	0.16
1993-94	-	-	45.03	-	0.21
1994-95	-	-	40.40	-	0.25
1995-96	2.75	20.90	47.05	13.16	-
1996-97	1.72	38.86	40.53	16.56	-
1997-98	1.42	28.97	38.95	15.79	0.18
1998-99	1.50	34.73	30.84	10.86	0.28
1999-00	8.47	41.11	20.25	4.77	0.38
2000-01	15.62	33.46	25.02	16.62	0.41
2001-02	11.27	76.29	26.77	15.63	0.58
2002-03	18.09	35.80	57.63	20.00	0.44
2003-04	8.20	25.65	41.92	13.49	0.45
2004-05	8.49	30.84	59.81	13.32	0.36
2005-06	-	-	-	-	0.49
2006-07	32.25	22.72	48.71	7.43	0.36
2007-08	-	-	32.11	-	0.36
2008-09	-	-	32.36	-	0.34
2009-10	3.37	20.11	46.46	11.62	0.46

Year	Bauxite	Chromite	Iron Ore	Manganese Ore	Coal
2010-11	0.91	4.00	22.64	3.24	0.80
2011-12	2.95	7.70	27.97	3.12	0.38
2012-13	25.27	6.93	13.26	3.08	0.45
2013-14	15.65	6.78	10.71	2.51	0.39
2014-15	30.27	1.17	5.66	0.47	0.20
2015-16	31.70	2.46	3.44	0.02	0.25
2016-17	11.28	6.18	16.00	0.01	0.27
2017-18	6.71	2.35	12.10	1.70	0.22

Source: Indian Minerals Yearbook, Reserve Bank of India and EPW_RF.

3.6 Conclusion

Mining sector contributes to the output, employment and trade of the economy. India has been producing so many minerals and using them to meet the internal demand and also exporting to various countries in the world. The value of mineral production has gone up starting from the time of independence. Among the mineral rich states Odisha contributes the most to the value of mineral production. GVA of M&Q sector has been increasing but its share in total GVA of the country has gone down since 1991-92. Total employment in mining has also declined steadily from 1992. We find a large gap between number of the men and women working in the sector. It has always been male dominated sector. Negative trade balance of the mining sector has been growing rapidly which is a serious concern for international trade in India.

Chapter 4

Physical and Monetary Asset Accounting of Mineral Resources in India

4.1 Introduction

It is widely acknowledged, by now, that contemporary national accounts suffer from narrowness in terms of the inclusion of information regarding environmental aspects of the economy, resulting in unsatisfactory measures of economic evaluation (NSO, 2013; Dasgupta, 2012a). Conventional GDP, which measures the output of an economy, does not correspond with the sustainable development policy formulation. GDP has gotten so much prominence that economic growth, by default, means growth in GDP (Dasgupta, 2013). Gundimeda et al. (2007) note that prevalent national accounts lack details of essential parts of national wealth, such as changes in quality of health, education, and environmental resources.

Target two of SDG 12 aims to achieve the sustainable management and efficient use of natural resources by 2030. Thus alternative measures commensurate with the sustainable development approach are needed to evaluate economic performance. An Essential feature of sustainable development is to take care of the need of the future generation. Rapid depletion of natural resources will affect the well-being of future generations adversely. Hence, understanding the interaction between the economy and the environment is essential for policy decisions regarding sustainable development (United Nations, 2014).

The literature on sustainable development emphasizes measuring the economy's wealth to keep track of the development process and sustainability (Pearce & Atkinson, 1993; Arrow et al., 2010; Dasgupta, 2012b; Atkinson et al., 2014). Wealth accounting, particularly in developing countries, would help direct policy decisions on sustainability. Environmental accounting based on the System of Environmental and Economic Accounting (SEEA) is very much helpful in tracking sustainability of resource consumption in an economy. Sustainable development approaches followed by different governments have motivated the alternative accounting system of comprehensive wealth (The World Bank, 2006). The economy's performance should be assessed in terms of growth or decline in the nation's wealth rather than GDP. Not even HDI, which is better than GDP, is considered a good measure of sustainability (NSO, 2013). Dasgupta (2012a) argues that human well-being should be the basis of economic evaluation.

Well-being, wealth, and sustainability are closely related to each other. Brundtland's report focuses on 'human needs' instead of well-being. Inter-generational well-being is dependent on the stocks of capital, i.e., wealth. Intergenerational equity is ensured if and only if the wealth of an economy increases. Measurement of wealth highlights the economy's productive base (Dasgupta, 2012a). The World Bank is trying to measure the wealth of nations and its changes to observe the long-term economic well-being of the countries(World Bank Group, 2018). The wealth of an economy comprises physical capital, human capital, natural capital, population, public knowledge, and institutions. It means the social worth of an economy's entire productive base. This wealth is called comprehensive wealth (Arrow et al., 2010). The most important contribution to wealth and sustainability is Pearce and Atkinson (1993), which discuss weak and strong sustainability. Weitzman (1976) argues, citing Samuelson, for a measure of "wealth like-magnitude." He laid the foundation of the green net national product (Kabir, 2017).

4.1.1 Environmental Assets as Productive Base

Environmental assets constitute a significant part of the productive base of the economy. The benefits of environmental assets are not being accounted for. The United Nations (2014) provides a framework accepted internationally to calculate environmental assets. It defines environmental assets as *"the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may benefit humanity" (p.134).* Environmental assets comprise individual components existing in the environment. Some of these components are directly used in economic activities. Some assets are harvested, extracted, and then used in economic production (ibid). The system of Environmental-Economic Accounting (SEEA) considers seven individual components of the environment as environmental assets. These components are (1) Mineral and energy resources, (2) Land, (3) Soil resources, (4) Timber resources, (5) Aquatic resources, (6) Other biological resources, and (7) Water resources.

It is necessary to consider the value of the above environmental assets to measure an economy's wealth. We can construct two accounts for environmental assets. First, the physical asset account provides the picture of existing resources in terms of physical units of measurement like tone. The second one is the monetary account. A monetary asset account can be constructed by valuing the physical assets available in the country. This provides information on resources in monetary terms.

4.2 . Review of Theoretical and Empirical Literature

4.2.1: International: Empirical Literature

If we don't account mineral resources as capital, it would lead to over exploitation or under exploitation of resource. This also results in incomplete analysis and policy formulation. The Bureau of Economic Analysis (BEA), follows two ideas to estimate mineral resources. (1) Satellite accounts should be consistent with the principles of economic theory. (2) The satellite accounts must reflect the interaction between environment and economy and these accounts should be consistent with standard national accounts. BEA prepares valuation of resources using four methods which depend on the estimates of normal return to invested capital, return to capital based on the market value of the capital stock in the oil industry and per unit capital cost of additions to the stock of reserve. The value of resource reserves and changes in reserves are estimated for the period 1958-1991 for major mineral resources using the four valuation methods: current rent, present discounted value, replacement cost and transaction price methods (Bureau of Economic Analysis, 1994).

In New Zealand, metallic and non-metallic mineral stocks are presented for the year 1997. The minerals monetary stock account shows asset values of New Zealand's economically exploited mineral resources and changes in value over time. Annual balance sheets are provided for the period 1994 to 2000 for gold, silver and iron sands and for aggregate, clay, limestone and dolomite. Net present value method given in SEEA for the valuation of mineral resources is used for the valuation purpose. Residual value method is adopted for calculation of resource rent. The annual resource rent owing to a natural resource can be estimated as the revenue generated from the use of the resource, less all costs incurred in generating that revenue, including return on capital (Statistics New Zealand, 2000).

Natural resource accounting deals with stocks and stock changes of natural assets, which comprise biological asset, subsoil assets, water, air, and land areas. In natural resource accounting, measurement in both physical and monetary units is necessary to obtain a more comprehensive picture of the changes in natural assets. Physical data are usually measured in units of weight. Monetary account can be constructed using three approaches: using environmental expenditure, using natural asset depreciation and doing full environmental accounting. Net present value approach is used to calculate the value of the mineral resources. Physical and monetary accounts of gold, platinum and coal are prepared for South Africa from 1980 to 2000 (Statistics South Africa, 2002).

Ryan, Thomson and Sincock (2003) describe the adjustment of national accounts for depletion and additions of mineral resources in Australia. The balance sheets of Australia accounts the value of environmental assets which are within the scope of asset boundary defined in SNA. The balance sheets consider the value of land, subsoil assets and standing timber. Net present value is used to value the mineral resources. In the year 2002 out of total assets calculated 36per cent was economic environmental assets. This is a huge portion that is missed in the conventional accounting resulting in undermining of contribution of environmental assets. Australian national accounts use NPV approach for valuation of natural resources. To calculate resource rent commodity prices and costs are used. Resource life is estimated by dividing stock by five year moving average of production. The account uses borrowing rate published by Reserve bank of Australia as discount rate. Between 1992 and 2002 net present value of subsoil assets has increased three times in Australia.

Department of Environmental Affairs, Botswana, (2007) considers mining sector as the backbone of the Botswana economy. Revenue generated from mineral resources is of critical importance for sustainable development. Botswana has been successful in avoiding resource curse and Dutch Disease[1]. The study covers accounting of diamond, copper/nickel and coal for Botswana. Resource rent is calculated for three major mineral resources. The mining sector has

[1] It is a concept to explain the relationship between the resource extraction and economic development. It says that the booming natural resource sector can lead to decline in the other tradable sectors like manufacturing and agriculture. Mostly the manufacturing sector. It reflects the imbalance among the different sectors due to discovery of natural resource. This occurs because of the disproportionate amount of labour diverted to the natural resource sector withdrawing from the manufacturing sector. The export competitiveness becomes worse because of the appreciation of real exchange rate. The term first appeared in The Economist to explain the complicated economic situation happened in The Netherlands after the rise of the natural gas sector in the country.

generated substantial amounts of resource rent, increasing considerably over time in nominal terms from P131 million in 1980 to over P10.3 billion in 2001. The mineral sector remains the major source of exports, government revenues and development in the country. Minerals accounts for over a third of GDP, almost half of government revenues and more than 80per cent of exports. Coal reserves are most significant and deplete very slowly as coal is mined for domestic use only. The reserves of both diamonds and copper/nickel have decreased by around 30 to 40per cent with an estimated lifetime of 19 and 3 years. While the physical reserves have declined, the value of the reserves has increased particularly for diamonds. This means that the mineral wealth of the country has increased despite extraction.

A system is required to connect the measurement of human economic activities to the environmental resources. This would help in measuring the sustainability of economic activities and economic growth. The mineral resource accounts provide physical, monetary and resource rents accounts consistent with the SNA. Statistics, South Africa uses SEEA framework to construct mineral accounts. Mineral accounts help in measuring sustainability of resources through depletion rate. Government, using this information, formulates strategic plans for economic growth without compromising in sustainable use of resources. The economy of South Africa has been depending more on mining as a driving force for the development. Mining continues to support and stimulate growth and development in the country. Statistics South Africa, 2012 presents the physical and monetary accounts of gold, platinum and coal from 1980 to 2009 (Statistics South Africa, 2012).

Wealth is defined as physical, natural, human and social capital. Income and wellbeing are dependent on wealth. In resources rich developing economies natural resources have been extracted to achieve high economic growth without making provisions for the future generation. Total national wealth accounts are being prepared for natural capital for Namibia. Resource rent and taxes collected are used to get monetary balance for the natural capital. Level of per capita wealth should not decline to maintain sustainable development. When we consume natural capital, it must convert into other capitals to produce wealth in future. It has been observed that in developing economies natural capitals are used for economic growth without having an alternative provision to generate wealth for future generation. Natural capital is a part of national wealth but it has not been included in conventional account system resulting in misleading the policy formulation (Lange, 2013).

Kabir (2017) tries to value three important natural resources of Bangladesh such as natural gas, coal and hard rock using SEEA framework. NPV approach is used for valuation of sub-soil mineral resources. It presents the physical balance and monetary balance sheets of the mineral resources. The paper strongly argues for the preparation of green accounts of the resources which would be useful for the policy making in the country. To prioritize preservation of exhaustible mineral resources for future generation, low social discount rate should be used. There is also risk of disappearance of mineral resources in a decade which are facing rapid depletion. The author throws light on the possibility of such happenings also. In case of Bangladesh, the author argues, future consumption of non-renewable resources would contribute more to national income, so Govt. should emphasize on the future value of the mineral resources.

Sopp and Leiman (2017) studied the accounting system in sub-Saharan African countries. Following UNSNA, 1993 many countries have started compiling satellite accounts. But policy makers have not taken the real message of these data. How policy makers have internalized the information given in satellite account can be tested. El Sarafy method which is based on Hick's view on income as time derivative of wealth is used to calculate resource rent from mineral resources. This study has been carried out for eight sub-Saharan African countries for the period of 1990-2015.

4. 2.2: International: Theoretical

Mineral resource stocks and environmental degradation are not considered in conventional GDP calculation. The BEA's accounting for mineral resources is an effort to value mineral resource stocks and to estimate the economic loss to society of depleting these stocks through mineral production. The use of current rent method can’t give explanation for the changes in national wealth or social welfare. Methods which consider depletion of resources should be used for accounting. Proper method should be applied to get valid and realistic results (Harris and Rieber, 1996).

Subsoil mineral resources have played key role in American economy. They are used as inputs to different sectors of the economy. Minerals are factors of production used in the production of many good and services. National income counts the production of minerals but fails to account the changes in the stocks of the resources. The production of minerals is no different from the production of consumer goods and capital goods. Therefore, economic accounts that fail to include mineral assets may seriously misrepresent trends in national income and wealth over time. There are three limitations in prevalent accounting system (1) additions to the stock of resource is not considered in production and asset account (2) depletion of the resources don’t get accounted and (3) contribution of minerals in the production of goods and services is ignored. There are three alternative approaches available for the valuation of subsoil resources: Transaction prices, Replacement value and Net present value method (Nordhous, 1999).

Davis and Moore (2000) argue that green accounting can significantly impact the accounts and macroeconomic policies of mineral based developing economies. Green accounting augments national accounts in two ways: first it adds the value of natural capital and second in calculation of net domestic product it not only considers depreciation of man-made capital but also considers depreciation and degradation of natural capital. Adjusting natural resource depletion to national accounts can reflect the sustainable level of income. This paper argues that the popular methods used to account mineral assets and depletion to adjust the national accounts are biased. Erroneous valuation of mineral stock will lead to bad economic policies like exclusion of value of stock from accounting mislead the policy decision. Hotelling valuation principle given by Miller and Upton, 1985 is used widely in valuing the reserve. The authors point out the restrictive assumptions behind the derivation of Hotelling Valuation Principle. Modified version of HVP is suggested which reflect the market information contained in observed mineral reserve transaction values. This modified version is based on benefits transfer approach and allows non-constant returns to scale and cumulative production effects. Net Present Value is preferred to HVP by World Bank and Canada, the authors say, indicating the shortcomings in HVP.

Cairns (2003) focuses on microeconomic analysis rather than macroeconomic model. Natural resources as form of capital contribute to the human well-being which is ignored in economic accounting. Most of the economists use macroeconomic optimization model for green accounting purpose. Hotelling macro model is conventionally used for the analysis of extraction and environmental accounting of nonrenewable resources. Microeconomic model has two major differences from macro model: first difference is about the assumption of the influence of natural and technological constraints of the firm and second difference is in the definitions of economic accounting magnitudes. The author gives emphasis on firm's decision rather than industry. Hence, micro model is needed. Micro model leads to optimal gross income, depreciation and net income from production.

Eurostat (2003) describes that subsoil asset accounts are part of integrated environmental and economic accounts. Stocks of subsoil assets are generally not known with certainty. Both the size of the deposits and the profitability of exploration are uncertain. There is no established international standard classification for subsoil assets. Different classification systems are used by the institutions compiling physical data, according to data availability and user needs. For preparation of monetary account resource rent should be calculated. The resource rent is the net income from extraction, defined as the value of output less all costs of extraction, including capital costs. The value of the stock of reserves should be estimated using the present value method.

Uberman (2014) argues that mineral resources have drawn attention of accountants both corporate and national. The former group has been facing a problem of different treatments of mineral resources in various national accounting standards leading to slow development of universally recognized rules under International Accounting Standard. The latter one struggles to include mineral resources into national accounts. There are important obstacles in identifying universally recognized methods of mineral assets valuation applicable in financial statement. The latest mostly used methods are given by SEEA framework. Natural resources are to be included into the accounts to make it possible to describe stocks and changes in stocks in monetary terms. Therefore issue of the valuation of this natural capital, the physical quantities and qualitative aspects becomes essential.

Galos et.al (2015) describes the mineral deposit as a unique object which depends upon the economic and technical parameters of the country. The deposits are not known with complete certainty. There is importance of estimating the mineral deposits to decide the desirability and economic viability of the mining activity and determine the development of the mining projects and their feasibility. The values of changes in the stocks are omitted in the calculation of national accounts in most countries. This omission leads to major anomalies and inaccuracies in the accounts. Like the depreciation of physical capital occurs in the production process, depletion of mineral reserve happen due to extraction of resources. The national accounts include the accumulation and depreciation of capital assets, but they do not consider the generation and depletion of mineral ones.

4.2.3: Environmental Accounting in India

In 2018 and 2019, CSO, Government of India published environmental statistics on various natural resources. These volumes provide information on the physical assets of existing mineral resources in the country. These reports encourage measuring the value of the mineral resources. (CSO, 2018 & 2019). Gundimeda et al.(2006) attempted to monetize the existing biodiversity in India. The monetary value of bio-prospecting, ecotourism, and non-use value of the forest is calculated. Gundimeda et al. (2005a) tried to give monetary value to India's physical agricultural cropland and pastureland. The adverse effects on soil are calculated in monetary terms. Kumar et al. (2006) discuss various ecological services of forests in India and measure the economic value of the ecological services of forests in India. Gundimeda et al.(2005b) estimated the forest products such as timber, carbon, fuelwood, and non-timber products in India. Kumar et al.(2007) compute the value of freshwater quality in India.

Studies on the environmental accounting for mineral resources of India are sparse. TERI (2006) used the SEEA approach to prepare the environmental accounting of coal resources for West Bengal and Madhya Pradesh. In 1994 The Energy Research Institute (TERI) constructed the physical and monetary asset accounts of coal for different coal-producing states of India, namely Orissa, Bihar, West Bengal, etc., and India as a whole. In 2001, TERI also constructed the physical and monetary asset accounts for some natural resources of Goa state (TERI, 2006).

Systematic research on mineral resources accounting in Indian context are few and far between. Although the Central Statistical Office of India has initiated some work on environmental accounting, it is not enough to understand the economy's wealth. Against this backdrop, we have attempted to create the physical and monetary asset account for Bauxite, Manganese Ore, and Iron Ore.

4.3: Physical Asset Account for Mineral Resources

"The term 'Mineral' means a class of substances occurring in nature, of definite chemical composition and usually, a characteristic crystal structure, but sometimes also includes rocks formed by these substances." (CSO, 2018 p.4.1). Minerals are extracted and transformed into specific economic use. Minerals are classified as fuel, metallic and non-metallic. The aim of constructing a physical account of resources is to know about the availability of a particular resource. It is necessary to keep track of the use of mineral resources, as their availability is finite in the environment. Mineral resources are extracted and used for economic activity, but those resources cannot be renewed on a human timescale. Mineral resources can be sustainable if a healthy balance is maintained between the additions to stock and extraction. Sustainable use of these non-renewable resources should be the priority of policymakers to ensure sustainable development.

Before constructing the physical asset account, it is essential to classify the existing stock of resources because they are not economically viable to extract. Two standard tools are available for this classification: (i) McKelvey Box and (ii) the United Nations Framework Classification (UNFC). Since 2003 government of India has been following the UNFC method. In UNFC, stocks are classified based on economic viability, geological knowledge, and feasibility study. Resources are classified into reserves and remaining resources. Reserve is that part of the resource that can be extracted economically in a country's existing technology, socio-political factors, etc. The rest of the resources are put under the category of remaining resources. Before moving to the construction of the asset account, we would like to give some information on the minerals available in different states of India. This information is given in table 4.1 .

Table 4.1 : Endowment of important Minerals in different Indian States

State	**Minerals**
Andhra Pradesh	Dolomite, Iron, Mica, China Clay, Manganese
Assam	Petroleum and Natural Gas, Coal
Chhatisgarh	Coal, Dolomite, Bauxite, Iron
Goa	Iron and Bauxite
Gujarat	Bauxite, Manganese, China Clay, Dolomite, Lignite, Limestone
Jharkhand	Coal, Bauxite, Iron, Copper, Manganese, Dolomite
Karnataka	Gold, Chromite, Iron, Dolomite, Copper
Madhya Pradesh	Coal, Diamond, Copper, Iron, Bauxite
Maharashtra	Dolomite, Bauxite, Coal, Iron
Odisha	Iron, Coal, Manganese, Bauxite
Rajasthan	Iron, Limestone, Copper, Lignite
Tamil Nadu	Lignite, Graphite, Bauxite
Telangana	Coal, Manganese, Limestone, China Clay, Iron
West Bengal	Coal, China Clay, Granite

Source: CSO (2018), EnviStats-India 2018, Central Statistics Office, Ministry of Statistics &Programme Implementation, Government of India.

SEEA central framework, 2012 has put guidelines for constructing a Physical Asset account of mineral resources. The account contains discoveries, reappraisals, reclassifications, extraction, and catastrophic losses. SEEA directs to build the asset account in the following way.

Table 4.2 Physical Asset Account for Mineral Resources

Opening Stock of Mineral resources
Additions to Stock
Discoveries
Upward reappraisals
Reclassifications
Total additions to stock
Reductions in Stock
Extractions
Catastrophic losses
Downward reappraisals
Reclassifications
Total reductions in stock
Closing Stock of mineral resources

Physical asset accounts give information about a particular mineral's opening stock and closing stock for an accounting period. The closing stock value of a year remains as the opening stock value of the following year. Closing stock of a year may be higher or lower than the opening stock value depending upon the value of additions to stock and reductions to stock. If additions to stock are more significant than the stock reductions, then closing stock would be higher than opening stock and vice versa. Additions to stock have three components: discoveries, upward reappraisals, and reclassification. Stock reductions have four elements: extraction, downward reappraisals, catastrophic losses, and reclassification.

(a)Government authorities explore minerals. New deposits of mineral resources found during a period are accounted for as discoveries. The new deposits must be known for consideration of discovery.

(b) Reappraisals may be upward or downward. Reassessment of the physical stock of resources `due to technology development can be done. This reassessment may lead to an increase or decrease in the mineral stocks. These changes brought by reassessment also relate to the quality of the resource and extraction viability of the resources.

(c) Extraction of minerals removes the resource from the deposit. Here the production of mineral data is taken as extraction value.

(d) Natural resources also get reduced due to catastrophic events that occur naturally and artificially. These losses are rare in mineral resources. In the case of forests, land, etc., the loss due to calamities is enormous. In the case of minerals, flooding and collapsing occur at mining sites. However, the recovery of the resources is also possible to a certain extent.

(e) Reclassification happens when the purpose of use of specific resource changes. This may lead to a reduction or increase in the value of the resource.

Table 4.3 Physical Asset Account of Iron Ore in India (in thousand tonnes)

Year	Opening Stock	Extraction	Closing Stock
1995	13460000	64507	13395493
2000	6311573	77604	6233969
2005	7062671	145942	6916729
2010	8093546	218553	7874993
2013	6606562	136618	6469944
2015	5421751	129321	5292430

Source: Indian Bureau of Mines and EPW-RF

Table 4.4 Physical Asset Account of Manganese Ore in India (in thousand tonnes)

Year	Opening Stock	Extraction	Closing Stock
1995	167309	1680	165629
2000	104541	1585	102956
2005	138151	2386	135765
2010	141979	2491	139488
2013	95871	2342	93529
2015	93475	2369	91106

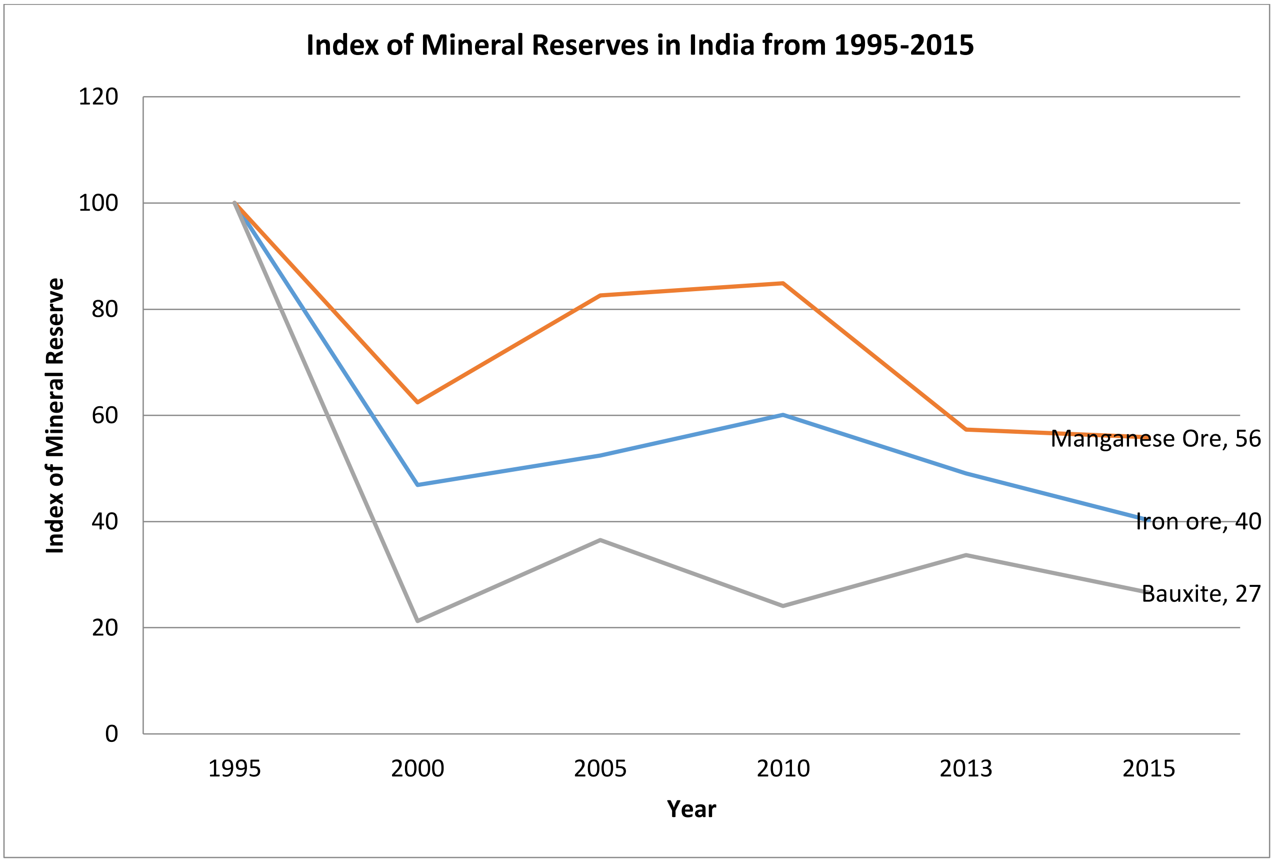
Source: Indian Bureau of Mines and EPW-RF

Table 4.5 Physical Asset Account of Bauxite in India (in thousand tonnes)

Year	Opening Stock	Extraction	Closing Stock
1995	2462431	4898	2457533
2000	524097	7053	517044
2005	899384	11964	887420
2010	592938	14124	578814
2013	830195	16507	813688
2015	656422	22493	633929

Source: Indian Bureau of Mines and EPWRF

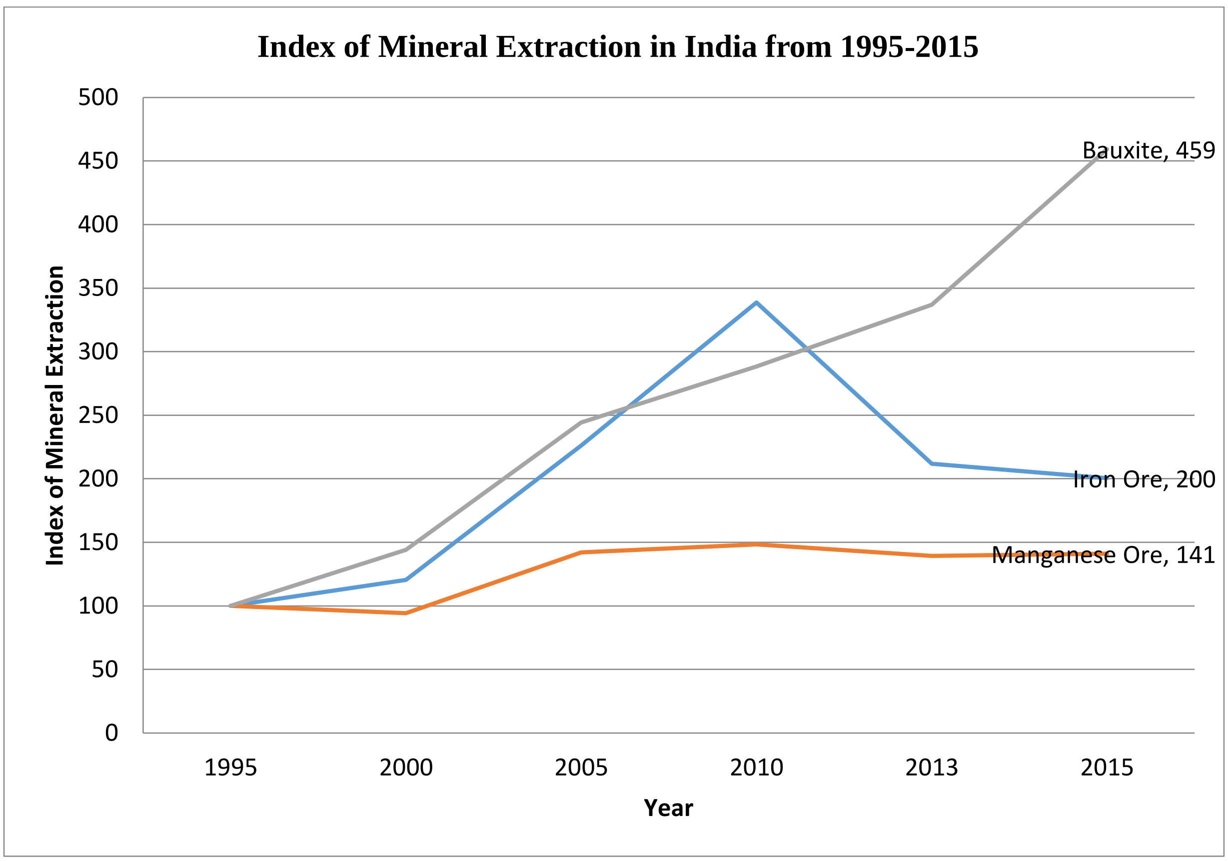
Figure 4.1 Index of Mineral Reserves in India from 1995-2015



Source: Authors' compilation from the data of IBM and EPWRF

Figure 4.1 shows trends in the reserve of iron ore, manganese ore, and bauxite. Reserves data are collected from Indian Minerals Yearbook and EPWRF website. To construct the index I have taken 1995 as the base year. Hence, in the figure the value for all the minerals in the year 1995 is 100. Reserves of all the minerals have declined from 1995 to 2015. The rate of decline in bauxite is higher than manganese ore and iron ore. Though there was an increase in iron ore reserve from 2000 to 2010, it started falling sharply from 2010. The same has been the case for manganese ore. The trend in bauxite shows higher fluctuations compared to other minerals.

Figure 4.2 Index of Mineral Extraction in India from 1995-2015



Source: Authors' compilation from the data of IBM and EPWRF

The declining trend in mineral reserves is a matter of concern. The trend shows that reserves are depleting very fast. We have been extracting the resource at a higher rate than the rate of additions to the stock. We know that the reproduction of non-renewable resources takes thousands of years through a natural process. If we continue to extract the minerals as we are doing now, it may reduce future generations' use of these resources, as clearly seen in the figure 4.1. The value of mineral reserves in monetary terms may be higher in the current period. However, the availability of resources in physical terms would decline for future generations, which goes against sustainable development.

Figure 4. 2 depicts the extraction path of iron ore, manganese ore, and bauxite. We have used the production of minerals data to display the extraction trend. The extraction of all minerals increased from 1995 to 2015. There was a phenomenal rise in iron ore extraction from 1995 to 2010 before declining sharply thereafter. Bauxite extraction has steadily increased during the entire period of our analysis. There was a marginal decline in the production of manganese ore between 1995 and 2000 before rising between 2000 and 2005 and remaining almost constant thereafter . Though there is no clear relationship between the extraction of mineral and its reserves, due to rapid extraction of minerals between 1995 and 2015 reserves have depleted. Generally, we expect an inverse relationship between extraction and reserve. The reasons for not getting a pattern of an inverse relationship between extraction and reserve throughout the period could be the role of other factors such as discoveries, reclassification, and reappraisals.

4.4: Monetary Asset Account of Mineral Resources

4.4.1 Valuation of mineral resources

Monetary valuation of environmental assets has many advantages. It helps to compare different environmental assets in terms of money, which is not permissible in physical accounts. The contribution of different environmental assets to the national wealth can be compared if and only if we have the monetary value of the assets. Furthermore, accordingly, governments can take steps to utilize those assets to optimize the production or extraction of resources. In most countries, governments have the ownership and regulatory rights over mineral resources over the extraction of the resources. So valuation of these assets in monetary terms may provide helpful information for assessing future income streams for the governments. It will help assess the current production of minerals and the future stream of income.

Generally, market prices are considered the value of an asset. Many environmental assets are not purchased and sold in the market. Hence they do not have observable prices. Even if there is an observable price for an asset, it does not always reflect all relevant aspects. Thus, while market prices allow comparison across asset types, those prices may not reflect the asset's value from an individual or societal perspective. Alternative approaches are available for the valuation of assets where the use of market price is not appropriate.

Net Price Method

In the Net Price Method, the resource value is calculated by multiplying the volume of reserve existing in the country with the difference between the average market value and cost of production per unit of the resource. As in the case of non-renewable resources, only proven reserves are considered, which are economically viable net prices for these stocks are always positive. This method is based on the Hotelling assumption (TERI, 2006).

Written-down replacement cost Method

SEEA also gives an alternative approach for the asset valuation called the written-down replacement cost method. This method is based on depreciation costs. The value of an asset is nothing but *"the current acquisition price of an equivalent new asset less the accumulated consumption of fixed capital over its life"*(United Nations, 2014, P. 151). We can use this method when reliable market price data for the resources are not available. In the case of environmental assets, this method can measure the value of fixed assets of cultivated biological resources (ibid).

Net Present Value

The most used method to value environmental assets is the net present value. The net present value approach is an alternative to the market price approach and is consistent with the System of National Accounts. In this method, the discounted value of future expected returns from the asset is measured. Following SEEA (United Nations, 2014), we have used the net present value method in this study. We have discussed the detail method in the following section.

4.4.2: Methodology and Data Sources

4.4.2.1 Net Present Value method:

The value of a stock of natural capital can be calculated as the discounted net present value of the income expected to be generated in the future from the same stock of natural capital till it gets exhausted. Thus, the value of a resource is determined by the unit resource rent, discount rate, and the life of the resource, i.e., the number of years that the resource is expected to last until exhaustion (TERI, 2006).

$$RV = RR\left[\frac{(1+r)^n - 1}{r(1+r)^n}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where,

RV: Present Value of the natural capital

RR: Resource Rent;

n: The life of the natural capital in years. This can be estimated from the ratio of the stock of the resource in physical terms and the annual rate of extraction, which is assumed to remain constant.

r: Discount rate.

4.4.2.1.1 Resource Rent Calculation:

Resource rent is an extra-economic return above the costs of extracting the mineral and occurs because of the scarcity of a resource. Surplus value is considered resource rent in the context of environmental assets. Resource rents reflect the value of a unit of mineral capital in the ground. There are three methods to calculate Resource Rent: Residual Value Method, Appropriation Method, and Access Price Method. The residual value method is adopted for this study.

Value of output for Manganese Ore, Iron Ore, and bauxite were collected from CSO, India, for the period 1995 and 2015. The value of output is in current prices for each year.

CSO, India provides Intermediate Consumption(IC) data for the mining and quarrying sector. Since IC is not available for producing any particular mineral, we compute it by an indirect method. First, the share of the total IC in the gross output of mining and quarrying is calculated for all the years. The range of the share is 21per cent to 44per cent. The value of IC for the individual mineral production is estimated by applying the percentage share, which is calculated for the mining and quarrying sector, in the value of the output of that particular mineral under the year. For example, the share of intermediate consumption in the total output of the mining and quarrying sector in the year 2013 is 41per cent. In 2013, the value of iron ore output was 49284 crore rupees. The value of IC in iron ore production in 2013 was 41per cent of 49284 crore rupees.

CSO, India also provides the data for compensations of employees (CoE), consumption of fixed capital (CFC), and net fixed capital stock (NFCS) for the mining and quarrying sector. A similar proportion method like that of IC is applied to compute the CoE and CFC data for individual minerals. To estimate the return to the produced capital, in this study, we have used the average lending rate given by RBI as given in Appendix A1.

Formula to estimate resource rent:

Value of output – Intermediate Consumption = Gross Value Added

Gross Value Added – Compensation of Employees = Gross Operating Surplus

Gross Operating Surplus – Consumption of Fixed Capital = Net Operating Surplus

Return to Produced Asset = Rate of Interest * Value of Produced Asset

Resource Rent = Net Operating Surplus – Return to Produced Asset

4.4.2.1.2 Life Expectancy of Resource

The life of natural resources plays a crucial role in understanding the sustainable use of the resources. The life expectancy of the resource significantly influences the present value of the resource. The life of a particular resource is calculated by dividing the reserve of the resource by the production amount in the physical term. Here, we have taken the proved and probable together as the resource reserve.

4.4.2.1.3 Discount Rate

The discount rate indicates the time preference of the asset owner, whether to receive the income now or in the future. The discount rate converts the future stream of expected income into present value. It is the expected rate of return on the asset. It is used to compare the future income or consumption with the present income and consumption occurring now (Stern, 2006). Choosing an appropriate discount rate has been a serious issue and matter of vigorous discussion among scholars (Zhuang, et.al. 2007).

Generally, individual and private enterprises prefer a higher rate of discount as they want a rapid return from the ownership of the asset. The social discount rate is lower than the market-based discount rate. Using the lower discount rate means we are giving more importance to the income earned by future generations. To maintain sustainable development, it is necessary to ensure a non-declining future flow of income. Hence, in the case of the environmental asset, it is recommended to use a lower discount rate (United Nations, 2014; TERI, 2006; Kabir,2017)). The central bank, i.e., the Reserve Bank of India, suggests using the weighted average interest rate as the discount rate in India. We find that the weighted average interest is too high in India, which may not be appropriate for environmental assets' net present value calculation. For iron ore, manganese ore, and bauxite, we find the weighted average interest rate as high as 10per cent.

4.4.3 Results

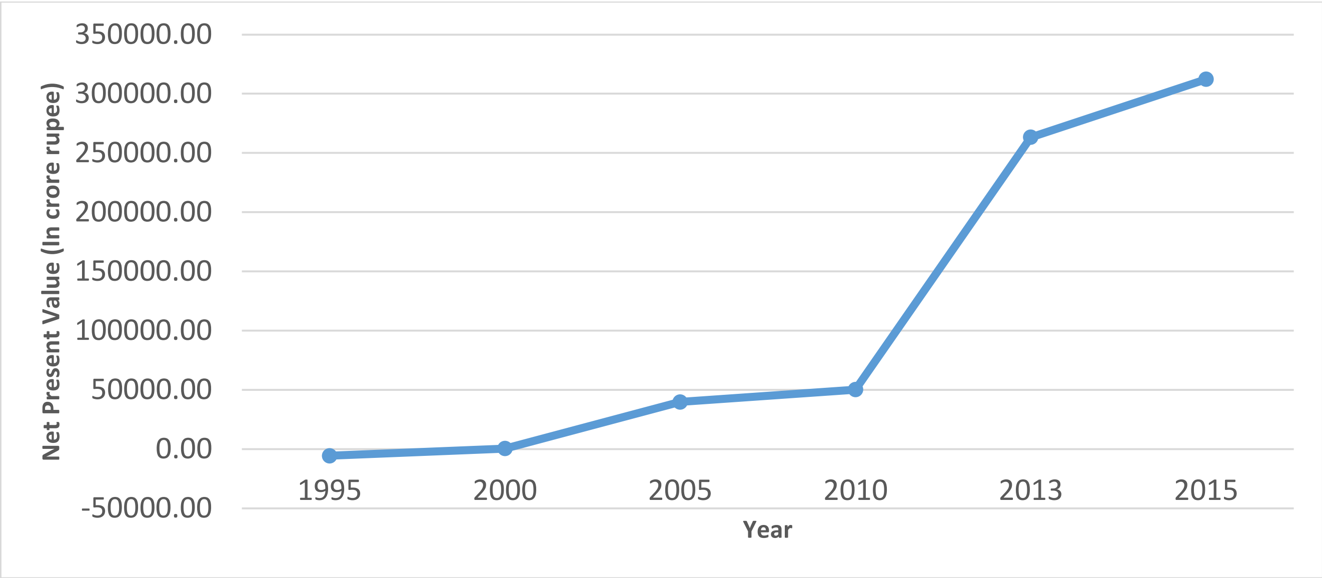
Table 4.6 Net Present Value of Iron Ore (in crore rupees)

	Years					
Iron Ore	1995	2000	2005	2010	2013	2015
Value of Output	1186	1924	7403	26462	49284	77832
Intermediate Consumption	319.75	405.44	1570.09	6472.27	20657.22	34737.15
Gross Value Added	866.25	1518.56	5832.91	19989.73	28626.78	43094.85
Compensation of Employees	286.96	605.51	1711.67	3980.56	7249.38	10239.63
Gross Operating Surplus	579.29	913.04	4121.24	16009.16	21377.39	32855.22
Consumption of Fixed Capital	193.49	338.34	990.85	4830.27	3612.47	6522.57
Net Operating Surplus	385.80	574.70	3130.39	11178.90	17764.92	26332.65
Net Fixed Capital Stock	3720.17	4590.91	14714.77	66720.12	74035.01	129882.89
Return to Produced Capital	558.02	562.39	1562.71	8920.48	7381.29	13144.15
Resource Rent	-172.22	12.32	1567.68	2258.42	10383.63	13188.50
Resource Life	208.66	81.33	48.39	37.03	48.36	41.92
NPV	-5728.77	373.46	39755.03	50085.19	263246.75	312284.71

Source: Authors' calculation using CSO data, Govt. of India, and data collected from different volumes of Indian Minerals Yearbook, IBM.

Thus the market-based discount rate does not give much importance to the income of future generations. Malhotra (2020) argues that there is lack of adoption and use of social discount rate. Developing counties are approaching towards the discount rate of the range of 3% to 7% (Campos, et.al. in Malhotra, 2020). Most of the researchers working in the context mineral resources of developing countries and underdeveloped countries in Asia and Africa have used 3% discount rate to calculate the present value or depletion cost. SEEA recommends using a lower discount rate. Therefore, we have used a 3per cent discount rate. The greater the value of the discount rate smaller would be the present value of the future stream of income.

Figure 4.3 Trends of NPV of Iron Ore



Source: Authors' calculation

The Net Present value of iron ore has increased significantly from 1995 to 2015. The rate of increase from 1995 to 2010 is slower than the rate of increase in the later period of 2010-2015. The substantial rise in the NPV from 2010 can be explained by the drastic rise in the prices of the minerals in 1995, the NPV value was negative because the resource rent from the iron ore production was negative. The negative resource rent resulted from the higher lending rate in 1995.

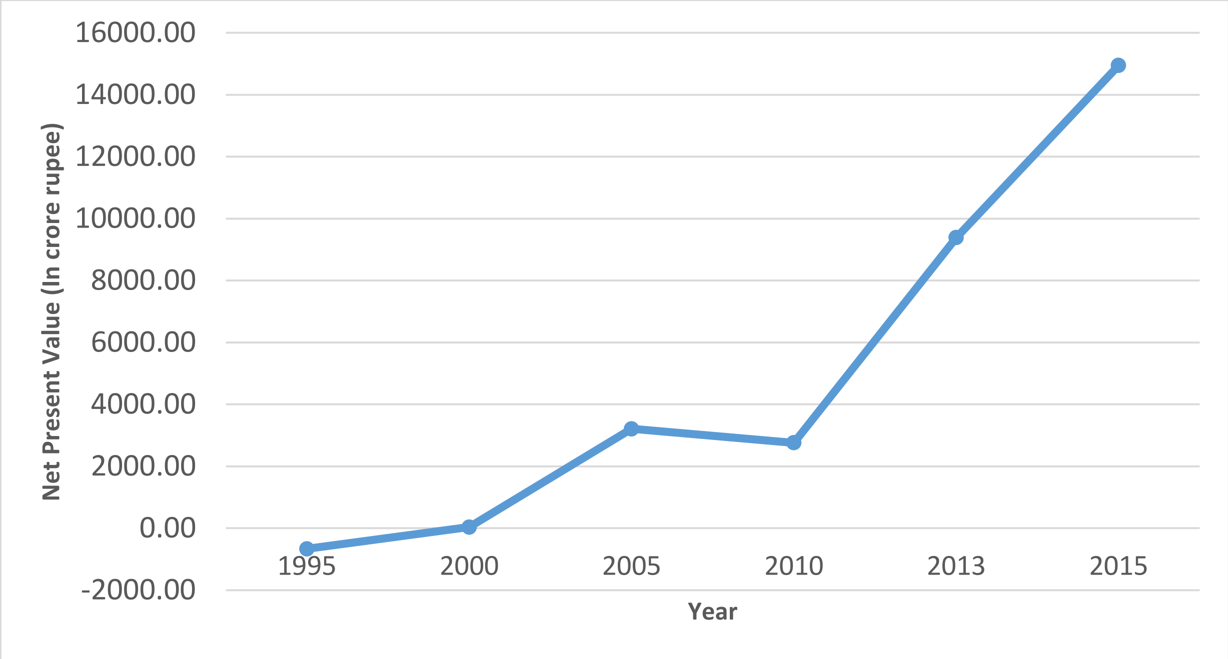
Return to produced capital as a share of NFCS was high in the year 1995 as compared to other years.

Table 4.7 Net Present Value of Manganese Ore (in crore rupees)

Indicators	Years					
Manganese Ore	1995	2000	2005	2010	2013	2015
Value of Output	145	193	555	1191	1927	3844
Intermediate Consumption	39.09	40.67	117.71	291.30	807.70	1715.61
Gross Value Added	105.91	152.33	437.29	899.70	1119.30	2128.39
Compensation of Employees	35.08	60.74	128.32	179.16	283.45	505.72
Gross Operating Surplus	70.82	91.59	308.97	720.54	835.85	1622.67
Consumption of Fixed Capital	23.66	33.94	74.28	217.40	141.25	322.14
Net Operating Surplus	47.17	57.65	234.68	503.14	694.61	1300.53
Net Fixed Capital Stock	454.83	460.52	1103.16	3002.93	2894.76	6414.71
Return to Produced Capital	68.22	56.41	117.16	401.49	288.61	649.17
Resource Rent	-21.06	1.24	117.53	101.65	406.00	651.36
Resource Life	99.59	65.96	57.90	57.00	40.94	39.46
NPV	-664.90	35.32	3210.08	2759.80	9384.58	14948.93

Source: Authors' calculation using CSO data, Govt. of India, and data collected from different volumes of Indian Minerals Yearbook, IBM.

Figure 4.4 Trends of NPV of Manganese Ore



Source: Authors' calculation

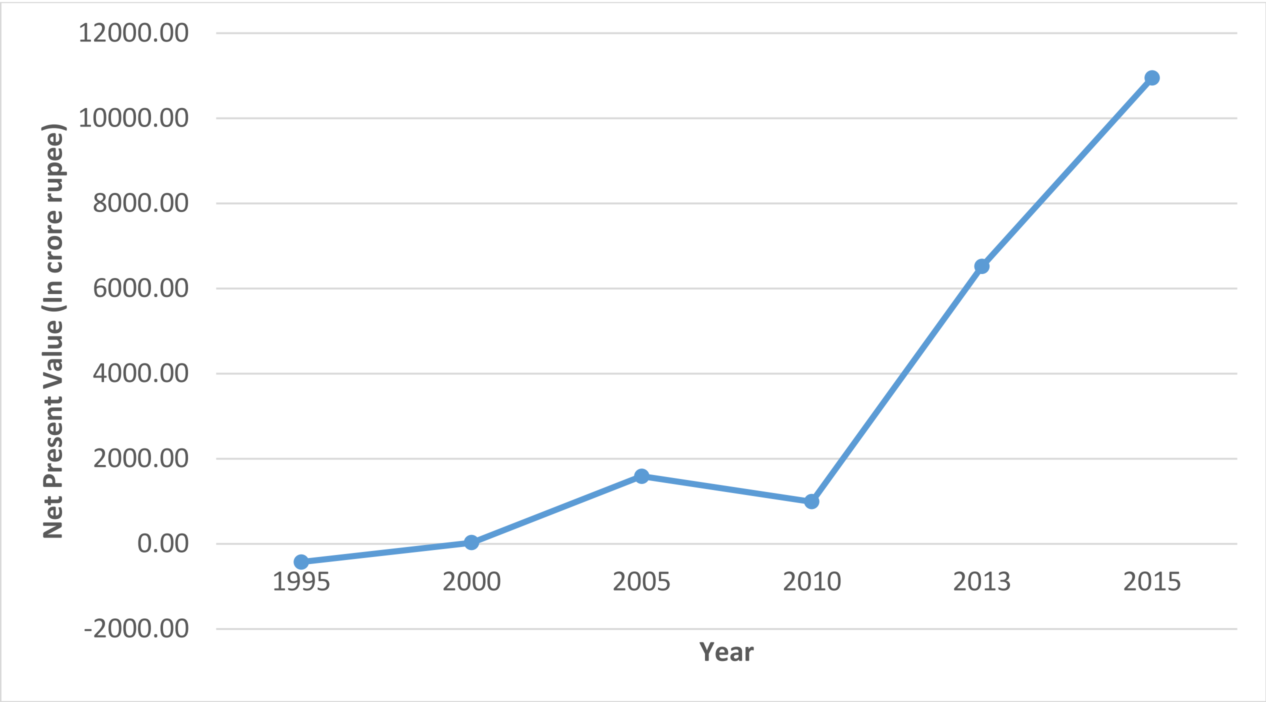
NPV of manganese ore demonstrates a significant rising trend from 1995 to 2015, barring a slowdown during 2005-2010. Though the resource life of manganese ore has remained almost the same in 2005 and 2010, there is a significant difference in the value of resource rent. Resource rent has declined from 2005 to 2010, resulting in a fall in NPV. Moreover, it could result from a higher interest rate in the year 2010, which is 13.37per cent, compared to the interest rate of 2005, which was 10.62per cent. NFCS was also greater in 2010 compared to 2005. The interest rate and NFCS were higher in 2010, which produced a higher return value on the produced asset. This also causes the smaller value of resource rent.

Table 4.8 Net Present Value of Bauxite (in crore rupees)

Indicators	Years					
Bauxite	1995	2000	2005	2010	2013	2015
Value of Output	89	130	252	489	1200	3354
Intermediate Consumption	24.00	27.39	53.45	119.60	502.98	1496.92
Gross Value Added	65.00	102.61	198.55	369.40	697.02	1857.08
Compensation of Employees	21.53	40.91	58.27	73.56	176.51	441.25
Gross Operating Surplus	43.47	61.69	140.29	295.84	520.51	1415.82
Consumption of Fixed Capital	14.52	22.86	33.73	89.26	87.96	281.08
Net Operating Surplus	28.95	38.83	106.56	206.58	432.55	1134.75
Net Fixed Capital Stock	279.17	310.20	500.89	1232.94	1802.65	5597.02
Return to Produced Capital	41.88	38.00	53.19	164.84	179.72	566.42
Resource Rent	-12.92	0.83	53.36	41.73	252.83	568.33
Resource Life	502.74	74.31	75.17	41.98	50.29	29.18
NPV	-430.80	24.66	1585.99	988.92	6521.60	10948.03

Source: Authors' calculation using CSO data, Govt. of India, and data collected from different volumes of Indian Minerals Yearbook, IBM.

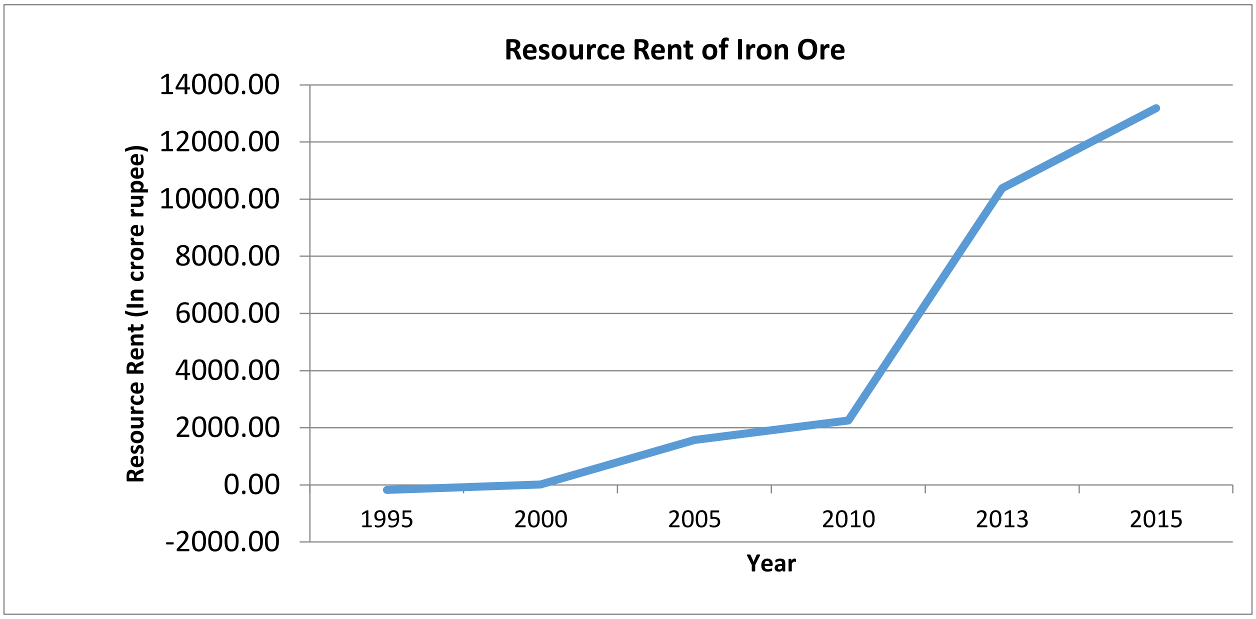
Figure 4.5 Trends of NPV of Bauxite



Source: Authors' calculation

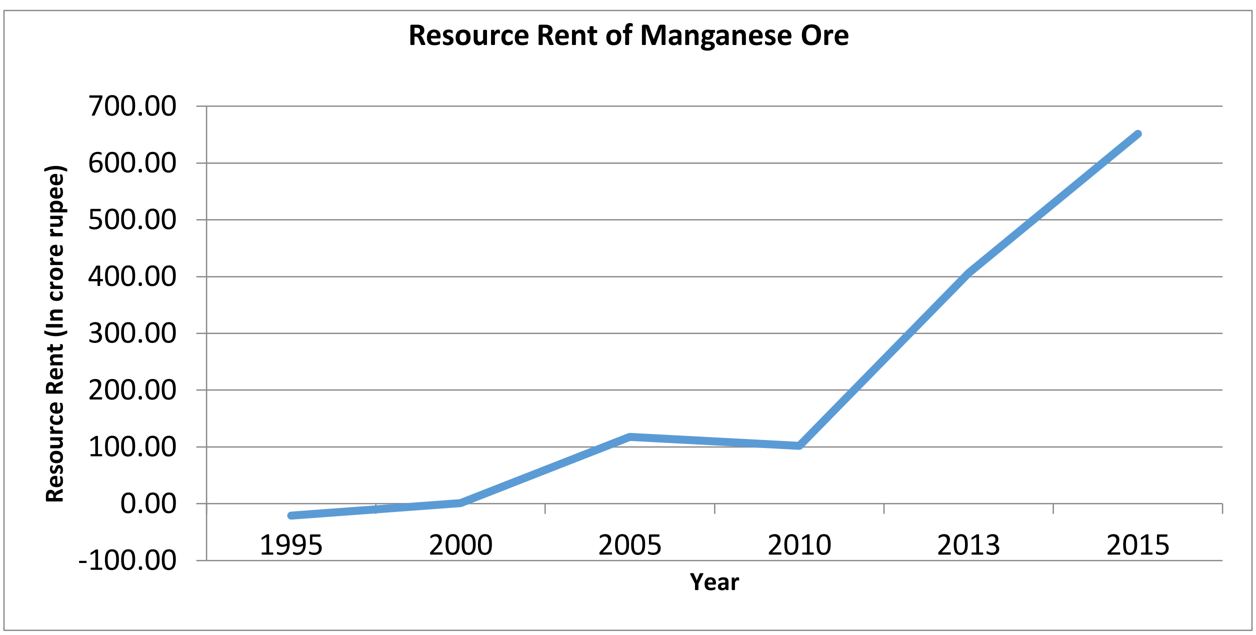
Like the case of iron ore and manganese ore, we also observe a drastic rise in the NPV of bauxite and a negative NPV in 1995. NPV for Bauxite declined from 2005 to 2010. This is because of the decline in both resource life and resource rent. Both the NFCS and interest rate were also higher in 2010 compared to 2005.

Figure 4.6 Resource Rent of Iron Ore



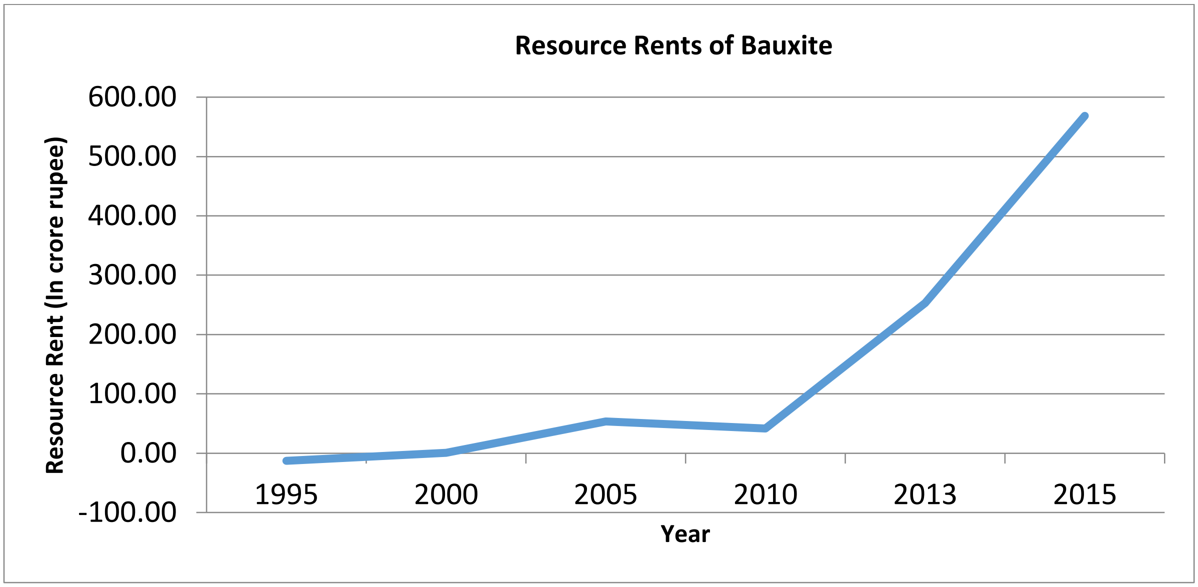
Source: Authors' calculation

Figure 4.7 Resource Rent of Manganese Ore



Source: Authors' calculation

Figure 4.8 Resource Rent of Bauxite



Source: Authors' calculation

Figure 4.6, 4.7, , and 4.8 show the trends in resource rents of iron ore, manganese ore, and bauxite, respectively. Resource rent reflects the profit of the production of mineral reserves. Negative resource rents in the initial year of 1995 for all mineral resources explain that the economy was at a loss by producing these minerals. This can be the result of the uneconomic extraction of resources. The lending rate in 1995 is also high compared to other years. This might cause a high value in return to produced capital as a share of total output value, causing a rise in the cost of production. Resource rent of Iron ore has increased during the entire period. Resource rents of manganese ore and bauxite have increased from 1995 to 2015 barring a slow down between 2005 and 2010 where resource rents have declined slightly.

4.5. Conclusion and Policy Reflections

Target two of SDG 12 aims to achieve the sustainable management and efficient use of natural resources by 2030. In this context wealth accounting at the national and sub-national levels is crucial to achieving sustainable development and ensuring intra-generation equity. The net present value of a mineral is the wealth of minerals existing at a particular time. Wealth accounting using the NPV approach provides an idea of the existing wealth of a particular resource (The World Bank, 2006). It shows the path to extract the resources at different discount rates (United Nations, 2014). The gross Domestic Product figure does not reflect the future use of any resources. It only gives us the partial economic value generated from a particular resource without any environmental stock and valuation information. Economic policies made without having information on total wealth and the future path of use of resources will undoubtedly lead to an unsustainable economy.

We found that the reserves of all mineral resources in India have declined from 1995 to 2015. This poses serious questions on the sustainable use of resources and intra-generation equity. The future generation will be worse off with fewer mineral resources. In physical terms, productivity or extractions of all the three minerals have increased significantly from 1995 to 2015. The extraction rate of bauxite has been much higher than iron ore and manganese ore. Though all the minerals gave negative resource rents to the economy in 1995, they turned positive in the subsequent years. Resource rents have increased remarkably. Because of negative resource rent in 1995, the NPV of all minerals was negative in 1995. Overall, the NPV of the resources has risen from 1995 to 2015 barring a slow down during 2005 to 2010. The substantial rise in the NPV and resource rent of all three minerals after 2010 can be explained by the drastic rise in the prices of minerals driven by global demand.

The Minerals are considered the economy's building blocks (CSO, 2018). Wealth accounting of natural resources also affects the economy’s fiscal policies (The World Bank, 2006). It provides different insights into understanding the fiscal space of the economy and managing the economic expenditures. Developing countries like India should encourage the development of mineral-based industries. The government of India should discourage the export of minerals and encourage value addition at the local level. This would help the country to generate more employment and income. The government of India should also frame strategic policies for higher investment in the exploration of minerals. Exploration of hidden minerals is necessary to gauge wealth and use the resources sustainably. A part of the profit coming from the mining industry should be invested in research and development activities for findings substitutes for the minerals.

Appendix A1: Lending Rates in India from 2004 to 2015.

Year	Min	Max	Average
2004	10.25	11	10.63
2005	10.25	11	10.63
2006	10.25	12.75	11.50
2007	12.25	14.75	13.50
2008	12.25	15.75	14.00
2009	11.5	16.75	14.13
2010	11	15.75	13.38
2011	8.25	9.5	8.88
2012	10	10.75	10.38
2013	9.7	10.25	9.98
2014	10	10.25	10.13
2015	10	10.25	10.13

Source: Reserve Bank of India.

Chapter 5

Environmental-cost Adjusted National Accounts for Mining Sector in India

5.1. Introduction

National Accounts, which systematically account for economic activities, are essential to evaluate the economy and formulate policies for economic growth. To measure national accounts, the United Nations' System of National Accounts (SNA, hereafter) gives the structure that is followed across countries to maintain uniformity and comparability. This conventional measure of national accounts is being challenged, particularly after the Brundtland commission report on sustainable development, due to its negligence towards environmental aspects of the economic activities. Human economic activities have environmental consequences such as pollution, natural resource depletion, destruction of biodiversity, etc. These are the environmental costs we have to bear for our economic activities. UNSNA does not consider these costs in the national accounts measurement process.

Non-accounting of environmental costs in national accounts raises several questions. Is present SNA helpful for maintaining sustainable economic development? If not, how can it be corrected to reflect the environmental aspects? Do we need a complete reconfiguration of national accounts? What can be the result of the faulty calculation of economic activities?

National income accounting was devised in the 1930s to govern macroeconomic policies. Gross Domestic Product (GDP) is defined as the value of the flow of goods and services produced in a financial year in the accounting system. It is used to compare the performance of economies. Net domestic product is calculated by deducting the value of the depreciation of physical capital from GDP. According to Weitzman (1976), net national product, i.e., GNP- Depreciation of physical capital, is the best measurement of the economy.

Nevertheless, it was realized later that these indicators lack the environmental elements of the economy. Environmental assets are ignored in the accounting system (Padhan and Das, 2021). Non-inclusion of the environment in national accounting happens in two ways. Firstly, non-inclusion of the value of goods and services provided by nature (Hueting, 1987), and secondly, not considering the depletion of natural capital (Elsarafy, 1989). The accounting process should consider the degradation of natural resources (Bartelmus and Tongeren, 1994).

Common and Sanyal (1998) argue that we need to have environmentally adjusted accounts to make policy for sustainable development. These accounts would lead us to understand the path of sustainability. Policies made using accounts that do not adjust the harmful effects of economic activities on the environment lead to unsustainability (Santos and Zaratan, 1997). Green GDP reflects both the economic and environmental conditions of the countries (Xu et al., 2010). Environmental accounting is necessary to guide policymakers to utilize the resources and protect the environment adequately. Dasgupta(2013) explains that the calculation of GDP is necessary but not sufficient to understand the welfare of the people.

To overcome this limitation in GDP measurement United Nations has initiated bringing alternative measurements. Handbook of Integrated Environmental and Economic Accounting was introduced in the 1993by United Nations. The latest version of the handbook, System of Environmental-Economic Accounting 2012_Central Framework (UNSEEA), provides an alternative measurement of national accounts that incorporate the environment (UN, 2014).

UNSEEA Central Framework classifies environmental assets into seven categories. These environmental assets are mineral and energy resources, land, soil, timber, aquatic, other biological, and water resources.

In this chapter, we have estimated the value of the depletion of coal resources and the environmental cost of coal mining in India and adjust it with the national accounts. Due to unavailability of sufficient data we could not take other minerals for analysis.

5.2. National Account System in India

The Central Statistical Office (CSO) of the Ministry of Statistics and Programme Implementation, India, constructs the national accounts for India and publishes them annually. It follows the production method to calculate the national income. Like SNA, we can see in the following box that CSO, India considers only the consumption of physical capital in measuring NDP.

Method for NDP Calculation by CSO, India:

Gross Value Added (GVA) at Factor Cost = Output – Intermediate Consumption

Gross Domestic Product (GDP) at Factor Cost = Sum of GVA at Factor Cost.

GDP at Market Prices = GDP at Factor Cost
+ (Taxes-subsidies) on production and export/import

= final consumption expenditures
+ Changes in inventories
+ Gross fixed capital formation
+ Acquisition less disposals of valuables
+ (Export of goods and services- imports of goods and services)

= Compensation of employees
+ Operating surplus/mixed income
+ Consumption of Fixed Capital (CFC)
+ (Taxes-Subsidies) on production and export/import

Net Domestic Product at Factor Cost/Market Price= GDP at Factor Cost/Market Price - CFC

Source: Central Statistical Office of India.

"*Consumption of Fixed Capital (CFC) is defined as the decline, during the accounting period, in the current value of the stock of fixed assets owned and used by a producer as a result of physical deterioration, normal obsolescence or normal accidental damage*"(Das; Padhan; and Sahoo, 2021). CFC here in the calculation of NDP represents only the consumption of physical capital. However, we also use natural capital in different forms during the production process. Due to this, nonrenewable natural resources get depleted. Overall accounting process by CSO, India ignores the depletion of natural resources. This exclusion of depletion of natural capital in NDP estimation leads to overestimation. Natural resources contribute a lot to the economy. Furthermore, the policies made from the national accounts that do not integrate degradation of the environment and depletion of natural resources encourage the unsustainable use of nonrenewable resources (TERI, 2006).

Understanding the interaction between the economy and the environment is essential for policy decisions regarding sustainable development. Impact of human activities on environment and climate is one of the major policy issues in contemporary period. On the other hand, economic growth of economies is highly dependent on the benefits deriving from the environment (SEEA, 2014). But the contributions of environment to the economic growth and human welfare have been ignored in national account system. Environmental costs resulting from human activities have not been accounted. National Accounts of a country which are measures of economic activities should incorporate the environmental benefits and cost. The System of National Accounts of United Nations prevalent and followed across the economies does not integrate the environmental aspects of an economy. To consider the value of environment and environmental costs in accounting system of the economy, United Nations developed a framework for all countries called Integrated Environmental and Economic Accounting (SEEA) in 1993.

5.3. Literature Review

Epstein (1996) discusses the integration of environmental cost into total cost of production and management of cost at company level. This paper develops a life-cycle costing or full environmental cost accounting model. Corporate environmental performance can be judged through the full environmental cost. Three types of costs should be included in product cost. These costs are current costs for past sins, current costs for current sins and future costs for current sins. Life cycle assessment and life cycle costing help in understanding the environmental effects of production carried by corporates. Epstein further argues that the companies that are not integrating the environmental impact in their business model are going to face increasing cost, loss of potential revenue earnings, and loss of competitive advantage. Hence, environmental cost accounting and incorporating in the decision making is beneficial for private companies as well.

Santos and Zaratan (1997) criticize the system of national account which fails to capture the adverse effect of extraction of non-renewable mineral resources. They calculate the depletion cost of gold and copper mining industry in Philippine from 1980 to 1990 using El Sarafy's user cost method. In copper industry the user cost varies from P 9 to P 136 million per year at the discount rate of 5per cent. The paper shows that greater the rate of discount lesser would be the vale user cost. So, from the perspective of sustainable development we should use the smaller discount rate to take care of the future generation.

Common and Sanyal (1998) argues that environmentally adjusted national accounts are required to judge whether our economic behavior is in accordance with the sustainability. For this we have to value the depreciation of natural resources in the economy. The authors have calculated the value of the depreciation of non-renewable resources in Australia from 1979 to 1995. They have used different methods like El Sarafy approach, Net Price and Net Present Value method to compare the depreciation values in Australia. It is commented that to get robust measure of depreciation is difficult and the depreciation value should be taken skeptically. This paper also raises question on the meaning and relevance of the resource accounting.

Turner and Tschirhart (1999) defines the gap between societal welfare and GDP as the welfare gap. We by default consider GDP as the welfare measurement. Non-marketed value of natural resource flow is not accounted for in GDP. The paper criticizes the growth model which considers only the income growth instead of welfare measure. In the model, the authors give emphasis on the natural amenities and natural capital.

Martinez-Alier (2001) argues that environmental externalities must be considered as part of the economy. Ecological distribution conflicts arises from the appropriation of resources and production of waste in the society. Martinez links the externalities with environmental justice movement around the world. There is a need of valuation of environmental costs such as loss of biodiversity, damage to human livelihood, etc. He discusses the international environmental liability of mining corporations.

Gundimeda et al. (2005) estimates the value of agricultural cropland and pastureland in India. They have assessed the costs of soil erosion, sedimentation and land degradation. Then NSDP was adjusted by monetary value of depletion and degradation to get ESDP.

Cairns (2006) opines that environmental accounting is an important instrument in social decision making in the country. He discusses the incorporation of both environmental benefit and cost into the economic accounting process. Green accounting helps in sustainable development policy formulation.

TERI(2006) uses the user cost approach to measure the depletion cost of coal mining in the states of Madhya Pradesh and West Bengal in India. The report adjusted the mining state domestic product (SDP) with depletion cost. In the year 2001-02, the share of user cost was 2.5per cent of mining SDP in Madhya Pradesh at 6per cent discount rate. For the state of West Bengal it was 0.1per cent.

A study by Gundimeda et al. (2006) attempts to give value to the bio-diversity functions of India's natural ecosystem. The authors have calculated the bio-prospecting values, ecotourism values and non-use values of forests in India. Loss/gain of these values has been adjusted to Net State Domestic Product (NSDP) to get Environmentally Adjusted State Domestic Product (ESDP).

Figueroa, et. al. (2010) measure the actual income from the metal mining sector in Peru. They use Hotteling rent approach to calculate the depletion of mineral resources. Environmental degradation cost is estimated. Both the costs are adjusted to get the green accounts. They find that the total loss due to mining ranges from 2per cent to 4.9per cent of Peru's GD and 31per cent to 51per cent of Peru's metal mining GDP. Conventional national accounts overestimate the income of the economy.

XU, YU, and YUE (2010) measure the green GDP of Wuyishan city of China. There are two ways of calculating green GDP. First type of accounting deducts the cost of environmental pollution and resources depletion from the conventional GDP. Second, we can value the services provided by ecosystem and add it to the traditional GDP. Measuring the ecological cost of economic activity is essential to maintain balance in the environment.

Muller, Mendelsohn and Nordhaus (2011) measure the value of the environmental externalities and compare it with the national accounts. They calculated the air pollution damage for different sectors of the US economy. Gross external damages (GED) and net external damages (NED) have been calculated. GED is equal to the marginal damages of emissions times total quantity of emissions. Costs of permits is deducted from GED to get NED. They find that the GED of mining sector is $3.3 billion per year in 2000 prices. The ratio of GED to value added of mining sector is 0.02.

Epstein, et.al (2011) calculate the full cost for the life cycle of coal. Due to extraction, transportation, processing and combustion of coal a lot of waste is generated that costs the environment. This cost is considered as external, as it is not internalized in the conventional cost measurement. The authors measure the full cost of life cycle effects of coal in the US. The value of externalities related coal is $345.3 billion in the year 2008.

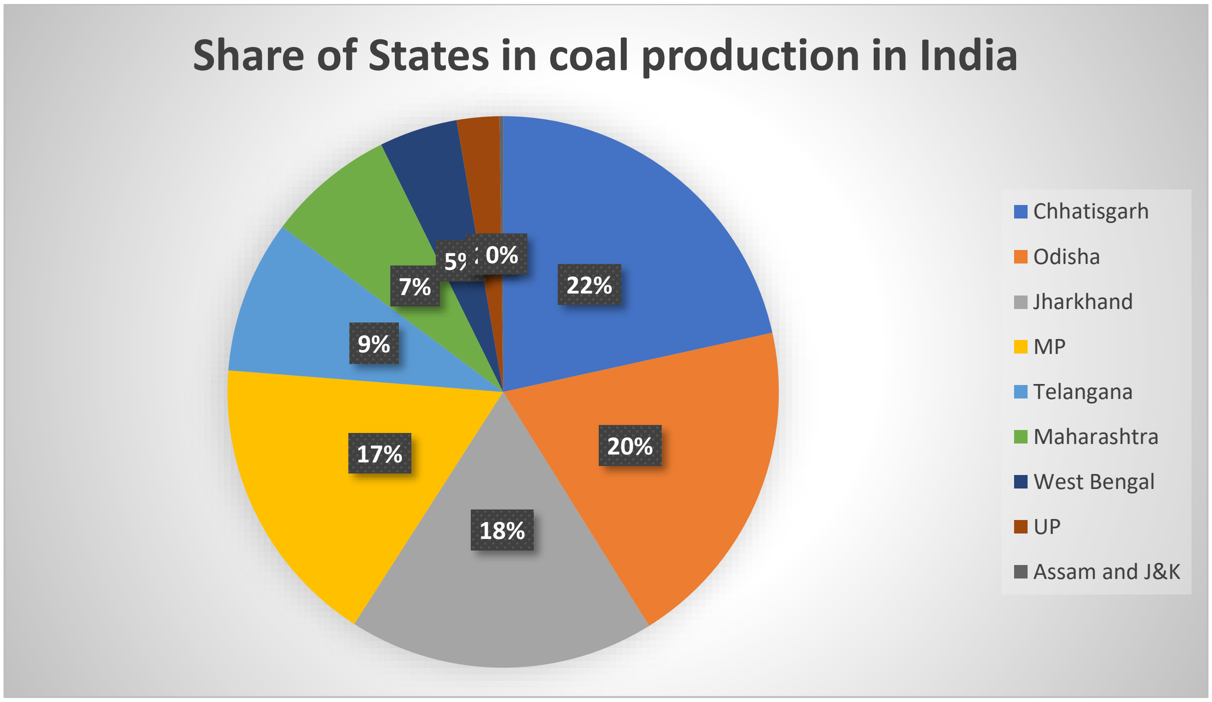
Cardoso (2015) identifies and value the different social and environmental liabilities of coal mining in Colombia. Social and environmental costs from mining are air pollution, soil mining waste, loss of water quality, loss of territory, loss of public health, losses due to coal transportation and loading, loss of human life, the user cost(loss of coal reserve) and the global cost of coal combustion. It is found that the cost of production per ton of coal is higher than the market price of coal per ton. And the major sources of costs are pollution, health hazard, depletion of water, loss of land and ecosystem services, damages from transportation and shipping and the user cost. The author strongly advocates the linking of environmental liabilities with the economic accounting. It would help in achieving environmental justice for local communities.

Zeng, He and Shi (2019) discusses the development of environmental cost accounting of mining industry in China. For environmental protection and cost management, they analyze the composition of environmental cost of mining and cost accounting process. Seven types of costs occur in mining industry. These are cost of coal consumption, exploration cost, environmental prevention cost, environmental governance cost, environmental impact cost, costs of ecological environment damage , and environmental management and education costs. In the accounting of cost process most of the problems arise from the environmental aspects of the mining.

5.4 Coal Production in India

Coal plays important role in economic growth. In India, it is used extensively for electricity generation. It is essential input for steel production. 55per cent of the total primary commercial energy comes from coal. 72per cent of the power generated in the country is coal based. During 2019-20, 89per cent of total coal was used in power sector. Many other industries such as cement, fertilizer, chemical, paper depend on coal for their energy requirement. In 2019-20, there was 0.30per cent increase in coal production in India. In the world, India ranked 2nd in coal production in 2019. The state of Chhattisgarh contributes 21.6per cent of total coal production of India which is the highest among all states. Odisha, Jharkhand, Madhya Pradesh, Telangana, Maharashtra, West Bengal, and Uttar Pradesh have share of 19.6per cent, 18per cent, 17.2per cent, 8.99per cent, 7.5per cent, 4.6per cent and 2.5per cent respectively in the total production of coal in India. Assam and Jammu &Kashmir produces 0.21per cent of total coal production (Indian Minerals Yearbook, 2020).

Figure 5.1: Share of states in total coal production in India in 2019.



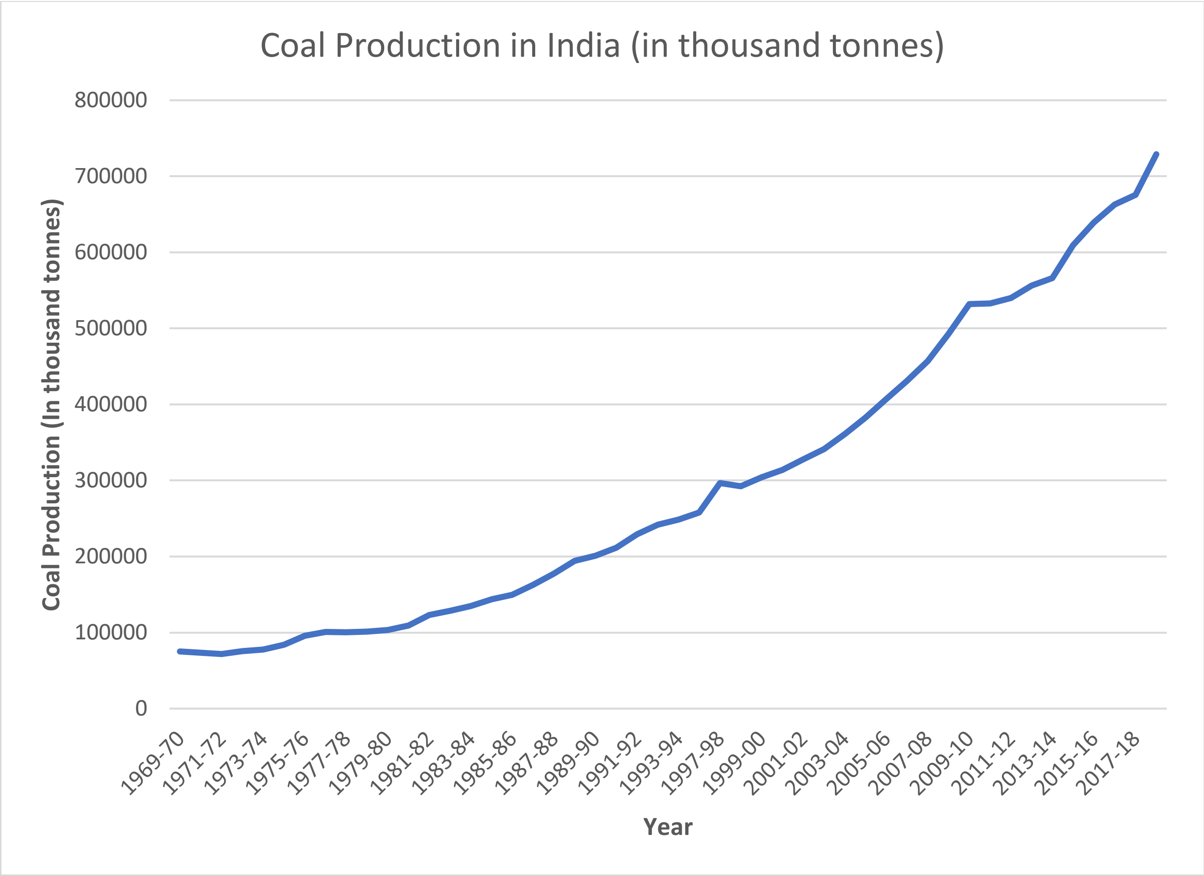
Source: Indian Minerals Yearbook, 2020

Table 5.1: Number of Coal mines in India and different States

State	2018-19	2019-20
India	454	442
Assam	4	3
Chhattisgarh	55	54
Jammu and Kashmir	2	2
Jharkhand	122	119
Madhya Pradesh	61	60
Maharashtra	58	54
Odisha	27	29
Telangana	50	46
Uttar Pradesh	5	5
West Bengal	70	70

Sources: Indian Minerals Yearbook, 2020.

Figure 5. 2: Trend in Coal Production of India.



Source: EPWRF and Indian Minerals Yearbook, 2020.

There is a decline in total number of coal mines in India in the year 2019-20. Jharkhand has the highest number of coal mines followed by West Bengal and Madhya Pradesh (see table 5.1). Figure 5.2 shows the trend in coal production in India in terms of quantity (tonnes). There is a phenomenal increase in coal production since 1969-70. Coal production has increased more than 800per cent since 1970. In the year 2019, 96per cent of the coal was produced by public sector and rest 4per cent by private sector.

5.5 . Accounting for the Depletion and Environmental Cost of Mining

In the current national accounts system, revenue from sales of mineral resources is considered value-added income or rent of the country (Harrison, 1989). However, mineral resources are non-renewable. More extraction of mineral resources at present means less availability of the resources for the future generation. This can lead to the depletion of the income of the future generation. The inclusion of revenue generated from sales of mineral resources goes toward extracting the resources as much as possible without taking care of future generations.

Hartwick (1990) says that to get the right NNP, we should subtract the value of depletion of mineral resources from GNP. The definition of capital should be expanded. Natural and human capital must be considered as the capital before constructing green accounts (Sara, 2002). Davis and Moore (2003) discuss the methods to estimate mineral depletion. Eugenio et al. (2002) calculate the green accounts of mineral resources in Chile. Santos and Zaratan (1997) estimate the depletion of copper and gold minerals in the Philippines. Daly (1989) provides the formula to calculate socially sustainable gross domestic product (SSGDP). The formula is SSGDP = GDP-User's Cost. User's cost is defined as the part of the revenue that must be invested to keep the future income level non-declining. According to XU, YU, and YUE (2010), green GDP has two types. One is to deduct the cost of pollution and depletion of natural resources from conventional GDP. Another one is to value the ecosystem services and integrate them with the GDP.

Dasgupta's report (2013) explains that variables like depletion of minerals and pollutant loads from mining are not included in India's National Account System. Mineral and energy resources are significant components of the environment. According to SEEA (2014), Mineral and Energy resources include oil resources, natural gas resources, coal & peat resources, non-metallic mineral resources, and metallic mineral resources. Depletion of these resources is not considered in calculating state GDP.

This chapter tries to calculate the Environmentally Adjusted Gross Value Added (EGVA) from Mining and Quarrying in India. I have estimated the depletion cost and pollution cost from mining in India from 2004 to 2015. EGVA can be calculated as follows:

EGVA= conventional GVA- (depletion cost + Pollution cost)

5.5.1 Estimation of Depletion Cost

Depletion cost is measured as User's Cost (UC). We have used El Sarafy's formula to estimate the User's cost. El Serafy (1989) divides total revenue from mineral extraction into two parts: Income and User's cost.

$$X/R = [1-(1+r)^{-N}] \quad \text{......(2)}$$

X: Income, R: Revenue from mineral extraction, N: Life Index of reserves, r: discount rate.

Restructuring the equation 2:

$$X = R\,[1-(1+r)^{-N}] \quad \text{......(3)}$$

UC can be calculated by deducting Income (X) from Revenue received from extraction (R)

$$UC = R-X = R - \{R\,[1-(1+r)^{-N}]\}$$

$$= R - \{R-R(1+r)^{-N}\}$$

$$= R - R + R(1+r)^{-N}$$

$$= R(1+r)^{-N}$$

$$= \frac{R}{(1+r)^{N}} \quad \text{......(4)}$$

Basic assumptions in the formula reflect the sustainability connection:

(a) The income component X is less than and equal to R, revenue received from the extraction of nonrenewable mineral resources. To maintain the future flow of income intact, we can consume the income part X.

(b) User's cost is the capital component of the revenue that should not be consumed. It should be invested for the perennial flow of future income. The future generation shall not suffer the income deterioration because of the present extraction of resources. In other words, all the User's costs must be invested to maintain income flow.

In the above formula, it is clear that proper governance of the extraction of a nonrenewable resource is required to ensure a sustainable flow of income for future generations.

5.5.1.1 Resource rent calculation

Due to the scarcity of non-renewable resources, resource rent occurs. Resource rent is the extra-economic rent received above the cost of extraction of the resource. Surplus value is considered resource rent in the context of environmental assets. Resource rents reflect the value of a unit of mineral capital in the ground. There are three methods to calculate Resource Rent: Residual Value Method, Appropriation Method, and Access Price Method (TERI, 2006).

The most commonly used method is the residual value method of these three methods. This method calculates the resource rent by "*deducting user costs of produced assets from gross operating surplus after adjustment for any specific subsidies and taxes"*(TERI, 2006). The appropriation method estimates the resource rent using the actual payments made to owners of environmental assets. The access price method uses purchases of licenses and quotas to extract mineral resources as resource rent. In this study, the residual value method has been followed.

We calculate the resource rent by deducting the consumption of fixed capital and return to the produced asset from the gross operating surplus (GOS). GOS is estimated as the residue in the gross value of output after adjusting for the value of intermediate consumption and compensation of employees. The value of output is in current prices for each year.

CSO provides Intermediate Consumption(IC) data for the mining and quarrying sector. Since IC is not available for producing any particular mineral, we compute it by indirect method. First, the share of the total IC in the gross output of mining and quarrying is calculated for all the years. The range of the share is 20per cent to 68per cent. The value of IC for the coal production is estimated by applying the percentage share, which is calculated for the mining and quarrying sector, in the value of the output of that particular mineral following the year.

CSO also provides the data for compensations of employees (CoE), consumption of fixed capital (CFC), and net fixed capital stock (NFCS) for mining and quarrying sectors. To get the data for coal mining, the same method is applied as IC. We use the average lending rate given by the Reserve Bank of India (as provided in appendix A1) to calculate the value of return to the produced asset.

Formula to estimate resource rent:

Value of output – Intermediate Consumption = Gross Value Added
Gross Value Added – Compensation of Employees = Gross Operating Surplus
Gross Operating Surplus – Consumption of Fixed Capital = Net Operating Surplus
Return to Produced Asset = Rate of Interest * Value of Produced Asset
Resource Rent = Net Operating Surplus – Return to Produced Asset

5.5.1.2 Life Expectancy of Resource

The ratio of a mineral reserve to the production of minerals gives us the life of the resource. The life of the resources depends upon the existing stock of the resource, volume of extraction, and the discoveries of the resource. The UNSEEA recommends using proven reserves or proven and probable taken together.

5.5.1.3 Discount Rate

The discount rate reflects the time preference of the person or authority who owns the asset. It shows whether the owner of the asset wants to extract more income from the asset in the present or in future. It helps in converting the future flow of income into present value. Generally, the market rate of discount rate is higher than the social discount rate. So individual and private enterprises prefer a higher rate of discount as they want a rapid return from the ownership of the asset. A lower discount rate gives importance to the need of the future generation. Higher the discount rate smaller would be the user cost and vice versa. A higher discount rate encourages the rapid extraction of mineral resources. To maintain sustainable development, it is necessary to ensure a non-decline future flow of income. Hence, in the case of the environmental asset, it is recommended to use a lower discount rate (United Nations, 2014; TERI, 2006). SEEA recommends using a lower discount rate. Therefore, we have used 3per cent discount rate to calculate the user cost.

5.5.2 Emission Calculation

The extraction of mineral resources emits several pollutions to the environment. Mining contributes to forest degradation, water pollution, air pollution, soil erosion, etc. (Das and Acharya, 2016). These adverse effects of mining are not accounted for in the national accounts. This omission of negative aspects of mining may result in faster extraction of mineral resources encouraging an unsustainable use of nonrenewable resources. This chapter calculates the methane emissions from Indian coal mining and handling activities. We follow the Intergovernmental Panel on Climate Change (IPCC) method to estimate the amount of methane emissions due to coal mining and handling in India from 2004 to 2015. IPCC provides methane emission factors for coal mining at the global level. However, it is good to use the country-level emission factor. For India, CSIR-CIMFR provides the emission factor for the underground and surface coal mining and handling activities. The volume of the annual production of coal data for different mining categories is collected from EPWRF and Indian Minerals yearbook. The value of annual coal production is multiplied by the methane emission factor and the conversion coefficient of 0.67 $Gg/10^6\ m^3$ to obtain estimates of methane emission from coal mining.

IPCC shows concern over data availability at different levels of the region. It provides methods to calculate the amount of emission at three different levels. These levels are tier one, tier two, and tier three. Depending upon the availability of quality data appropriate tier should be used. Data availability and complicacies vary from country to country and region to region. Here, we use the tier one method to estimate methane emission. In the tier one method, activity data, i.e., production of minerals, is taken at a country level and multiplied with the conversion and methane emissions to get the volume of coal mining emissions. Emission factors are different for underground and surface coal mining.

Tier one method for Underground coal mining (IPCC, 2019)

CH_4 emissions = CH_4 emission factor

* Underground coal production

* Conversion factor

Table 5.2: Emissions factor for coal mining and handling in India (CSIR-CIMFR)

	Degree I	Degree II	Degree III
Mining	2.91	13.08	23.68
Post-mining	0.98	2.15	3.12
Conversion factor	: 0.67 $Gg/10^6\ m^3$		

Source: Ministry of Environment, Forest and Climate Change, Government of India. (MoEFCC, 2015).

According to Singh and Kumar (2016), underground coal mines in India are classified into Degree I, Degree II, and Degree III by the Directorate General of Mines Safety. In degree I underground coal, less than one cubic meter of methane is emitted to the environment per tonne of coal production. One tonne production of degree II underground coal produces more than one cubic meter and less than ten cubic meters of methane. For degree III, underground coal methane emission is more than ten cubic meters per tonne (Singh and Kumar, 2016).

Table 5.3: Distribution of underground working coal mines in India

Underground coal output by degree (million tonnes)			
Year	Degree 1	Degree 2	Degree 3
2004	44.46	15.42	2.03
2005	44.03	18.18	1.88
2006	43.57	16.00	1.65
2007	47.51	13.03	1.76
2008	49.77	15.38	1.14
2009	53.76	12.17	0.89
2010	55.32	13.82	0.86
2011	55.41	11.54	2.08
2012	51.37	12.29	0.69
2013	52.18	11.48	1.08
2014	52.70	10.64	1.02
2015	54.91	9.61	0.39

Source: EPWRF

In table 5.3, it is clear that within the underground coal mining degree 1 coal production dominates all the years. There is a massive gap between the degree one coal output and the other two categories of coal. Environmentally, this is good for the economy as the production of degree one coal emits less methane per tonne than degrees two and three. Degree one coal production has increased substantially from 2004 to 2015. In contrast, in degrees two and three, coal output that emits a high amount of methane per tonne has gone down.

Tier1 method for surface coal mining

CH_4 emissions = CH_4 emission factor

* Opencast coal production

* Conversion factor

Emissions factor for coal mining and handling in India

(CSIR-CIMFR)

Mining 1.18

Post-mining 0.15

Conversion factor: 0.67 $Gg/10^6\ m^3$

Table 5.4: Opencast Coal Production in India

Opencast coal output (in million tonnes)	
Year	Output
2004	317.97
2005	356.76
2006	339.64
2007	384.81
2008	407.65
2009	491.98
2010	494.55
2011	498.06
2012	507.38
2013	480.30
2014	540.11
2015	577.65

Source: EPWRF and Indian Minerals Yearbooks.

In India, most coal is produced from opencast coal mines, as we can see in table 5.3 and table 5.4. We can observe from table 5.3 that there is a phenomenal rise in opencast coal production from 2004 to 2015.

We calculate the methane emission from both the underground and opencast coal output. To value the emission, we convert the methane into carbon dioxide (CO_2) following the AR5 of IPCC

(2019). According to AR5 of IPCC, one methane (CH_4) equals 28 CO_2 equivalents, corresponding to 100 years of global warming potential (GWP_{100}). CO_2 is valued according to the social cost of carbon measured by Ricke et al. (2018). In India, the social cost of carbon equals US $ 86 per tonne of CO_2. Using purchasing power parity (PPP), we convert the US$ into Indian Rupee. PPP data from 2004 to 2015 is collected OECD website (Link: https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm). I have calculated the share (in percentage terms) of the cost of environmental pollution from coal mining in total value of coal output. It varies from 4.5 per cent to 3 per cent. I have used these percentage values to calculate the pollution cost for mining and quarrying sector, assuming that production of other minerals also release same percentage of emission to the environment. Applying these percentage values to the GVA of mining and quarrying, I get the value of pollution cost for the mining sector.

5.6 Results

Table 5.5: User Cost of coal output

Year	Life Index (years)	Total rent(in crore rupees)	User Cost (in rupee)
2004	680	7446.60	0.00
2005	648	8071.78	0.00
2006	622	7818.78	0.00
2007	596	8347.46	0.00
2008	563	6597.27	0.00
2009	542	4292.09	0.00
2010	518	5815.04	0.00
2011	532	18781.36	0.00
2012	543	-21888.55	0.00
2013	537	20813.78	0.00
2014	533	16816.14	0.00
2015	503	17975.21	0.00

Source: Authors' calculation from CSO, India data.

Table 5.5 provides the depletion in the coal industry estimated using the User's cost approach. The user's cost must be deducted from conventional national accounts. Here we can see that depletion or User's cost is zero in all these years from 2004 to 2015. It is because the life index of coal reserves for all the years is high, varying from 503 to 680. However, the life index is declining throughout the years in consideration. This trend implies that we need to be careful in using coal resources. 3per cent discount rate is used to measure the user cost. The higher the discount rate lower is the User's cost. The high value of the discount rate gives preference to the present use of the resources. Total rent, i.e., the value of output minus the cost of production, has increased from 2004 to 2015 except in the year 2012. In 2012, the cost of production was too high, resulting in negative rent. This means that in coal production, the economy has incurred a loss in the year 2012.

Table 5.6: Methane Emission (in teragram) from coal production in India

Year	UM	U-PM	SM	S-PM	Total in teragram
2004	0.254	0.056	0.251	0.032	0.593
2005	0.275	0.059	0.282	0.036	0.652
2006	0.251	0.055	0.269	0.034	0.609
2007	0.235	0.054	0.304	0.039	0.631
2008	0.250	0.057	0.322	0.041	0.670
2009	0.226	0.055	0.389	0.049	0.719
2010	0.243	0.058	0.391	0.050	0.741
2011	0.242	0.057	0.394	0.050	0.743
2012	0.219	0.053	0.401	0.051	0.724
2013	0.220	0.053	0.380	0.048	0.701
2014	0.212	0.052	0.427	0.054	0.746
2015	0.198	0.051	0.457	0.058	0.763

Source: Authors' calculation using data from EPW-RF and Indian Minerals Yearbooks, IBM.

Notes: UM: Underground mining; U-PM: Underground post-mining and handling; SM: Surface mining; S-PM: Surface post-mining and handling.

Table 5. 6 demonstrates that the total methane emission from coal production has increased from 2004 to 2015. This is because of the rising volume of coal output in both surface and underground mines. Methane emission from surface mining has a significant share of the total emission. Nevertheless, if we compare the volume of output produced through underground mining and surface mining per tonne of coal output, underground mining has been more polluting than surface

mining. For instance, in 2013, in the production of 64.75 million tonnes of coal in underground mines, 0.273 teragrams of methane were emitted. In the same year, 480.30 million tonnes were produced in opencast mines, and the methane emission was 0.428. Emission this year is almost double in surface mining. However, surface mining production volume is almost seven times more than that of underground mining.

Table 5.7: Valuation of the emission

Year	CO_2 in tonne	SCC in US Dollar	PPP	E_cost (Rupee crore)	E_Cost of coal as per cent of total value of coal output
2004	16607726.08	1428264443	10.46	1494.38	4.5%
2005	18254097.2	1569852360	10.71	1682.46	4.4%
2006	17053307.92	1466584481	11.27	1653.78	3.9%
2007	17675268.04	1520073051	11.74	1785.18	4.2%
2008	18768464.71	1614087965	12.57	2030.38	4.2%
2009	20123118.48	1730588190	13.36	2312.56	4.0%
2010	20756473.81	1785056747	14.59	2606.06	3.8%
2011	20814630.43	1790058217	15.54	2783.45	4.0%
2012	20263156.96	1742631498	16.16	2816.23	4.0%
2013	19617499.07	1687104920	17.34	2925.83	3.0%
2014	20876449.26	1795374636	18.38	3301.07	3.3%
2015	21363037.91	1837221260	19.23	3533.89	3.3%

Source: Authors' calculation from the OECD data on PPP and SCC data from Ricke et al. 2018.

Note: SCC: Social Cost of Carbon, PPP: Purchasing Power Parity.

Table 5.8 Adjusted Gross Value Added

Year	GVA of M &Q (in crore)	E_Cost as per cent of GVA of M & Q	E_cost of M&Q Sector (in crore)	Green GVA of M&Q= GVA -E_cost of M&Q Sector (in crore)
2004	70704.2	4.5%	3200.73	67503.46
2005	93758.82	4.4%	4136.51	89622.31
2006	110532.87	3.9%	4343.94	106188.9
2007	128998.96	4.2%	5441.04	123557.9
2008	149210.42	4.2%	6256.79	142953.6
2009	163961.65	4.0%	6562.89	157398.8
2010	193262.73	3.8%	7381.06	185881.7
2011	251303.03	4.0%	10038.34	241264.7
2012	261035	4.0%	10439.61	250595.4
2013	285842	3.0%	8462.78	277379.2
2014	295794	3.3%	9800.05	285993.9
2015	308476	3.3%	10271.2	298204.7

Source: Authors' calculation using data from CSO, India.

Note: GVA of M&Q: Gross Value Added from mining and quarrying sector in India; E_cost: Environmental cost.

The value of emission i.e. environmental cost has increased significantly from 2004 to 2015, as shown in table 5.7. CO_2 has also gone up. Table 5.8 presents the adjusted Gross Value Added (GVA) from mining and quarrying. GVA is given in current prices. It has grown throughout the time period of our analysis. The environmental cost as percentage of GVA varies from 4.5 per cent to 3.0 per cent. Environmental cost of mining has reached its highest in the year of 2012. The environmental cost occurred in this year was the value of Rs.10439.61 crore. This cost is not internalized in the national accounts. It should be considered in accounting. The last column provides the environmentally adjusted GVA from mining and quarrying.

5.7 . Policy Implications: Cost of Production, Price and Carbon Tax

Coal production has several adverse environmental impacts. Some of these impacts are air pollution, deforestation, soil erosion, water pollution, etc. Coal extraction involves removal of top soil, which leads to soil erosion, loss of fertility, destruction of habitat and pollution. There are reports of arsenic problems in the ground water in the coal mining areas. Acid mine drainage accelerates dissolve of heavy metals that subsequently seep into the ground water table and surface water. Increase in the suspended particulate matters in the coal region causes various lungs diseases.

Burning of coal for energy generation produces suspended particulate matter, ground level ozone, smog, and acid rain. Thermal power plants produce huge quantities of fly ash into the atmosphere. Combination of all pollutants in the coal mining and thermal power plants cause greenhouse effect and hence raise the temperature. Coal burning produces several harmful gases namely carbon dioxide, nitrogen oxide, methane gas and sulfur dioxide. All these harmful gases contribute significantly to global warming and climate change.

Due to these negative consequences on environment, people particularly living near the mining areas suffer a number of pollution related health problems. Health cost due to mining could be very high if calculated carefully. Except these costs, displacement and dispossession are common in mining areas. In case of displacement, mining firms are required to provide adequate compensation to offset the direct costs. Nevertheless, indirect costs, especially environmental costs, are never included in the compensation calculation. For example in case of acquisition of common property resources by the mines displaced households do not receive any compensation. All these costs are not included in conventional economic cost of production. This non-inclusion of the environmental and social costs leads to over consumption of minerals, inappropriate pricing of energy and adverse selection of energy sources.

According to Murty (2001) there are two instruments to manage the environment and protect it from the unlimited extraction of natural resources. One is non-market instrument which is also known as command and controls method. Another is economic instrument that comprises of 3 instruments, namely price based, quantity based, and hybrid instruments.

Realizing the negative externalities of coal and preparing a smooth transition towards clean energy sources, the government of India has started imposing cess on coal since 2010. Government collected Rs 50 per tonne in 2010 and increased to Rs 100 in 2014, Rs. 200 in 2015 and Rs 400 in 2016 (Petri, 2020). Is this amount of cess sufficient to offset the environmental damages and social costs? There are no comprehensive studies that estimates the total environmental cost of mining. Our study focuses only on the methane gas emission from coal mines.

Table 5.9: Cost of coal production in India

Year	Coal production (in crore tonne)	Conventional cost of production (rupees per tonne)	E-cost (rupees per tonne)	Coal cess per ton (in rupees)
2004	36.12	707.76	41.37	-
2005	38.26	785.76	43.97	-
2006	40.7	841.82	40.63	-
2007	43.09	788.50	41.43	-
2008	45.7	915.16	44.43	-
2009	49.27	1085.51	46.94	-
2010	53.21	1173.11	48.98	50
2011	53.27	955.52	52.25	50
2012	53.91	1712.23	52.24	50
2013	55.64	1402.05	52.59	50
2014	56.58	1463.77	58.34	100
2015	60.92	1447.11	58.01	200

Source: Authors' calculation.

Note: E-cost: Environmental cost. Only methane emission cost is considered.

Column 3 in table 5.9 provides the economic cost calculated in conventional approach. This cost includes compensation to employees, intermediate consumption, consumption of fixed capital, and return to produced capital. Central Statistical Office of India provide the data of these costs. But it does not have any data on environmental cost of mining. This clearly shows that the policy decisions taken on the basis of these measurements of costs are not compatible for environmental friendly policies. We try to calculate a segment of environmental cost of coal production. This cost is provided in the fourth column of the table. From 2004 to 2015 the environmental cost of production of per ton of coal has increased significantly. There is 41per cent increase in the environmental cost during this period.

The cess imposed on coal should reflect the environmental cost borne by the society. In the year 2010, the amount of cess levied on coal was Rs. 50 per tonne and the estimated environmental cost Rs. 48.98.The environmental cost that we have calculated here is just one part of the several environmental aspects. If all these costs, as discussed in the second paragraph of this section, are computed, the cess/tax would be much lower than the cost. We therefore suggest that the tax imposed on coal should be reflective of the environmental cost borne by the society. Therefore, comprehensive studies should be conducted to measure the total environmental cost and efforts should be made to collect the matching amount of environmental tax/ces.

5.8 . Conclusion

In this chapter , we have calculated the depletion and environmental costs of coal, then adjusted these costs with conventional GVA from the mining and quarrying sector in India. Measurement of depletion cost as represented by User's cost here is essential for policymakers to differentiate the income and capital components of the revenue from mining. The capital part of the revenue must not be consumed. It should be invested for future income generation. Measurement of depletion cost would guide monitoring the management of environmental resources. We find zero depletion cost of coal mining in India because of the high level of coal reserves present in the country. However, the trend in the life index of coal warns us to use it judiciously to maintain sustainability. The environmental cost is calculated and adjusted to GVA from mining and quarrying. The environmental cost, which includes only the social cost of methane emission was as high as Rs 10439.61 crore in 2012. At this moment, we encourage other researchers and government and non-government agencies to calculate the overall cost of production of all the mineral resources in the country. Researchers may face problems in data availability and methodological issues. Government agencies like Central Statistical Office, should initiate this environmental cost accounting for all minerals. This would promote sustainable use of mineral resources that takes care of the intra general and intergeneration equity. Imposition of cess on coal is definitely a welcome step to factor in the environmental cost in the price of coal and ensure smooth transition from coal to other clean energy sources. Nevertheless, the cess can be increased further to cover the total environmental cost of coal.

Chapter 6

Sustainability of Mining in Indian States

6.1 Introduction

Greening the national accounts is an inevitable part of sustainable development policy formulation. National accounts such as gross domestic product, saving, investment, etc. in conventional accounting system lack information of the environmental impacts of human economic activities (NSO, 2013). In the previous chapter we have calculated the environmentally adjusted gross value added (GVA) by deducting the value of the emission from coal mining in India and depletion of the coal resource from the conventional GVA. GVA is a production identity in the national account system which reflects the output contribution to the economy. This process of greening the accounts should be extended to other indicators of the economy.

Saving and investment play crucial role in the capital formation in an economy. Capital formation is vital for economic growth. In the prevalent accounting system, only the produced capital is taken into consideration. Other kinds of capital such as natural capital, human capital are neglected in the process of accounting. This may result in overestimation or underestimation of capital formation. Green accounting tries to incorporate all types of capital assets. In this chapter we try to measure the saving which is inclusive of human capital and the depletion of natural capital.

Hamilton and Clemens (1999) argues that overestimation of saving and wealth is critical to conceptualizing and achieving the sustainable development. In the measurement of national savings we are still ignoring the depletion of natural resources and the degradation of environment. Green accounting literature is growing because of development of new techniques of calculations of the natural resource depletion and environmental degradation. Theoretical foundation for green accounting has been laid mostly by Weitzman (1976), Hartwick (1990), and Maler (1991). For the first time the green accounting method was applied to calculate the net saving by Pearce and Atkinson in 1993 (Hamilton and Clemens, 1999). Pearce and Atkinson (1993) measured the actual saving for twenty countries by adjusting the conventional national saving with the value of degradation and depletion costs. They find most of the countries having unsustainable saving trend.

Gross National Income (GNI) at market price = GDP at market prices +(Taxes – subsidies) on production and Imports +compensation of employees (net receivable from abroad) + property income (net receivable from abroad) Net National Income (NNI) at market prices = GNI at market prices – consumption of fixed capital (CFC) Net National Disposable Income (NNDI) = NNI+net taxes on income and wealth receivable from abroad +net social contributions and benefits receivable from abroad Net Saving = NNDI – final consumption expenditure +net equity of households on pension funds receivable from abroad+net capital transfer available Changes in net worth due to savings and capital transfers = Net saving+Capital transfer receivable Net savings + net capital transfers receivable = Gross fixed capital formation – CFC +Changes in inventories +Acquisitions less disposals of valuables And non-produced non-financial assets + net lending/net borrowing Net lending (+)/borrowing(-) = net acquisitions of financial assets less net incurrence of financial liabilities

Source: CSO, 2012 (Method and sources)

Saving is defined as "*the excess of current income over current expenditure of the various sector of the economy. For the closed economy saving equals capital formation during the year whereas* *for the open economy saving equals capital formation plus net capital inflow from abroad during the year"*(CSO, 2012). This definition by Central Statistical Office of India adheres to the standard national saving definition by current United Nations System of National Accounts. It is clearly understood from the definition that saving is not inclusive of environmental aspects of the economy. Income and expenditure, in conventional method, are also devoid of environmental impacts of economic activities. Saving, income, and investment identities of the economy in conventional accounting system is given in the following box.

In the saving identities, we can see that in the calculation of net saving consumption of fixed capital is deducted. However, in this method only physical capital is considered and natural capital and human capital are ignored. Hamilton and Clemens (1999) opine that depletion of natural capital should not be part of the net saving or net income of the economy. It should be deducted and not figured as a positive contribution to the economy. On the other hand, human capital is omitted from saving entities. Knowledge, skills and experience of people of nation are also part of the capital base of the economy. Spending on education and health should be considered as investment.

6.1.1 The idea of Sustainability and its development

Maintaining inter-generational equity is the central point in the idea of sustainability. Economists started focusing on sustainability aspect of the economy by incorporating the non-renewable natural resources in the standard economic growth model. How a finite stock of natural resource can contribute to the generation of a flow of constant per-capita consumption over time? This question brought the idea of sustainability to economic studies (Figueroa and others, 2010). Growth of the economy at present must not occur at the cost of the less availability of resources for the future generation.

Solow (1974) tried to find a path which allows the extraction of finite natural resources with sustainable economic growth. He studied the case of exhaustible oil resource. He included both natural capital and physical capital in the economic model to understand the substitutability. He concluded that indefinite economic growth can be maintained even if there is exhaustion of natural resources if there is increase in the reproducible physical capital. Physical capital can play as a substitute to the natural capital for the economic growth. Society can have a constant level of consumption forever by manufacturing physical capital which would replace the natural capital. This idea of substitution between physical capital and natural capital to keep the economy growing is called weak sustainability.

Hartwick (1977) argues that a development process is sustainable if there is a constant per-capita consumption flow. To achieve this we need to invest all the present profits gained from the extraction of exhaustible natural resources on the formation of manmade (physical) capital. For Hartwick the condition for intergenerational equity is that "*total value of the net investment be equal to zero at all times"* (Cairns, 2006). This is called as Hartwick Rule. Solow (1986) explains that Hartwick condition of sustainability holds when there is constant stock of total capital over a period of time. Total capital comprises of physical capital, human capital, and natural capital.

London School Approach on sustainability is based on the identification of critical non-substitutable natural resources. These resources must be preserved. The propounders of this argument include David Pearce, Giles Atkinson and Kerry Turner. There is also a Safe Minimum Approach for maintaining sustainability. According to this approach, no natural capital should be extracted below a safe minimum standard. Herman Daly in 1990 came up with guidelines to sustainably use the non-renewable natural resources. Human scale should be limited to the carrying capacity of the nature. Technological progress should help in increasing efficiency. Waste generated through economic activities should not cross the assimilative capacity of the nature. Exhaustible resources should be extracted at a rate which is less or equal to the generation of renewable substitutes (Kadekodi, 2001).

6.2 Literature Review: Sustainability of mining

6.2.1 Theoretical Literature

One-fourth of the developing countries are mineral economies. Mineral economy is defined as the economy which gets at least 10per cent of its gross domestic product from mining sector and at least 40per cent of its foreign exchange from mineral exports. It is very tough to achieve sustainability in mineral economies because of Dutch disease. It is difficult to generate the physical capital enough to compensate the depletion of natural resources, which is the basic principle of sustainability to maintain the consumption level intact over a period of time. In mineral economies it is a mistake to argue for the generation of capital which would be substitute of depleting mineral resources (Auty, 1993).

Hilson (2000) reviews the mining sustainable development policies of Canada. He gives an account of the initiatives taken by mining industry of Canada. Candian mining industry is a success story of achieving sustainable development.

Eggert (2001) reviews the literature on the contribution of mining to the economy. Focus is given to the economic aspects and sustainability of the benefits coming from the mining sector. The major question raised in the study is that can we govern mineral income to enhance the economic benefits for long period of time. We have to answer this question from the national and local economy point of views.

Poor governance in developing countries are resulting in reckless extraction of exhaustible mineral resources. Policy paralysis prevails due to the abundant natural resource availability. In developing countries large part of gross domestic product comes from primary sector. Natural resource rents are not properly governed to contribute to the economic growth for long period of time and environmental sustainability. Sustainable management of renewable resources, non-renewable resource and pollution sink should be the goal of environmental policies. The economy would not be sustainable with defective macroeconomic policies (Auty, 2003).

Azapagi (2004) opines that in the industry sector it is the mining industry which faces most sustainability questions. It has to address the sustainability concerns of all stakeholders. Azapagi tries to establish a framework for sustainability indicators to evaluate the performance and improvements of the mining sector. This framework incorporates the social, environmental, economic and integrated indicators of the economy. He has developed indicators to evaluate sustainability in the metallic, construction and industrial mineral subsectors.

Esteves (2008) investigates the role of mining industries in social development. Local community development is assumed to be the responsibility of governments. Companies don't show interest in facilitating the local development. To evaluate the social projects by mining companies a social investment decision analysis tool is built. Social impact assessment helps in decision making which looks beyond the profit making business of the companies and contributes to the social development.

Ghorbani and Kuan (2016) looked into the sustainable development of mining sector in Chile. They suggest to improve the water and energy management and the policy in compliance with social and environmental impact assessment. Chilean government is performing well in implementing environmental policies to achieve social growth.

Bui, et.al (2017) developed a framework to assess sustainability of mining sector in Asia-Pacific Economic Cooperation region at national and global scale. Fuzzy logic has been applied in the framework to handle the uncertainty and ambiguity. Indicator based sustainability assessment framework helps in avoiding the uncertainty and vagueness in decision making. This study follows the criteria of economic, environmental and social performance. And considers twenty indicators to understand the reality of mining sector in the economy. The study identifies the crucial elements which are contributing to the sustainability and suggests in which sector of the economy the countries should invest to improve sustainability.

Alves, et.al (2020) analysed the social, economic and environmental impacts of mining in Brazil. Sustainability of mining sector is scrutinised taking these aspects into consideration. This study is based on mining companies of Brazil. Authors found that less number of mining companies are taking sustainability initiatives. There are gap between big companies and small companies in terms of awareness about the sustainability practice.

Yamaguchi (2021) discussed the capital based indicators of sustainability. Two majorly followed indicators are wealth and genuine saving. Spatial dimension is introduced to the sustainability measurement. Hotteling and Hartwick rules of investment are incorporated with spatial diffusion of natural capital.

Aureliean, et.al (2022) scrutinized the impact of existing mining rights in Zambia on the distribution of economic benefits among the stakeholders of copper mining project. The mining industry in Zambia has a lot of scope to better the sustainability. Equitable distribution is necessary for sustainable development.

6.2.2 Empirical Literature

Does mining sector contribute to the sustainable development in the developing economies? Stern (1995) evaluates whether mining sector adds positive value to the economy or prevents economy to achieve sustainable development. Vector auto-regression model is used to study the case of 19 developing economies. The author calculated the multiplier of mining income on gross national product. Out of the 19 economies in most of the cases mining sector has contributed to the sustainability.

Lange (2002) measures the wealth of mineral resources as a measure of sustainability in Botswana by using the net present value approach. He argues that calculation of wealth is not sufficient to judge sustainability. We have to track the spending pattern in the economy. Depletion of mineral should be compensated by the generation of man-made capital. Sustainable Budget Index which is the ratio of non-investment spending to recurrent revenue is calculated for 1976 to 2001. It is found that Botswana is spending well in the reinvestment which is good for the economy in future. But a better allocation of mineral income is needed to improve the sustainability.

Lins and Horwitz (2007) analyze the key sustainability issues of mining sector in Brazil. 13 indicators under the category of social, environmental and economic & governance are used to examine five large companies. It is found that most sustainable companies are those focusing on the improvement in eco-efficiency and social practices.

Figueroa, et.al (2010) calculates the actual income of the mining sector in Peru from 1992 to 2006. They use Hamilton approach of green economic income. They measure the value of environmental degradation and depletion of mineral resources to get the natural capital loss of the economy due to mining. Natural capital loss varies from 2per cent to 4.9per cent of the GDP of Peru. The paper also discusses the sustainable income from the mining sector.

Dialga(2017) establishes a sustainability index of mining countries following the Hartwick's weak sustainability approach. Five dimensions such as economic, social, environmental, transverse and institutional are included in the index. The index is used to analyze the situation of mining sector in Burkina Faso and Niger. It is found that Niger's index number is smaller than Burkina Faso.

Famiyeh, et.al (2020) focuses on the encouraging factors and hurdles to implement the sustainability practice of mining companies in Ghana. They discuss the effectiveness of coercive and normative pressure. These pressures have effective impacts on three different kinds of sustainability such as economic, social and environmental. It is found in the study that normal institutional pressure only impacts the environmental and social sustainability but not the economic one.

6.3 Sustainability of mining sector in India

Mineral resources are important environmental assets for the economy (UN, 2014). Natural capital is a chief component of wealth of the nation and productive base of the economy (Dasgupta, 2012b; Arrow, et.el., 2010; Padhan and Das, 2021). Mineral resources play vital role in economic growth. Minerals are building blocks of Indian economy (CSO, 2018). Mining, immensely, contribute to the process of industrialisation of the economy. It generates employment (Hota and Behera, 2016) output, and revenue (Das and Acharya, 2016) for the economy. Jobs and income created in mining industries have helped in alleviating poverty in local communities (Huang, Zhou and Ali, 2011). Export of minerals to the rest of the world helps in maintaining a favourable trade balance and foreign exchange. In developing countries, in recent past, 'governments of extractive economies' have tried to obtain benefits from mining industries to accelerate the development of the economy (Castano, et.al., 2019). Low and middle-income countries having abundant minerals have taken advantage of rising prices of minerals to foster economic growth (McMahon and Moreira).

Exhaustible mineral resources if not managed properly and left to reckless extraction may lead to exhaustion of the resources. Future generation may not be able to enjoy the resources that we are accessing now from the environment. Hence, judicious mining practice and use of the benefits from the mining is essential to make the economy sustainable. Though there are some studies on the contribution of mining sector to Indian economy and different state economies, we don't find any research on the evaluation of sustainability of mining sector of Indian states. In this study, we try to evaluate the economic sustainability of mining sector of Indian states.

6.3.1 Methodology

Sustainability is a multi-dimensional concept. Three major dimensions of sustainability are economic, social and environmental (Bui,et.al 2017; Azapagi,2004; Alves, et.al 2020; Dialga, 2017). Wealth and genuine saving are two commonly used indicators for economic sustainability (Hamilton and Clemens, 1999; Yamaguchi, 2021; Figueroa, et.al , 2010). Both are capital based indicators. Wealth is the social value of capital base of the economy. Capital base comprises of physical capital, natural capital, human capital, population, public knowledge and institutions (Arrow, et.al, 2010; Padhan and Das, 2022, Dasgupta, 2012). In chapter 4 we have calculated the wealth of mineral resources in India. Wealth of mineral resources has been calculated using the production identities of the national accounts. Saving and investment identities are important to understand the capital formation in the economy. Weak sustainability advocated by Solow (1974) and Hartwick (1977) is based on the substitution between natural capital and physical capital. Contribution of human capital to the economy must be taken into account. Generally, expenditure on health and education is considered as human capital. Spending on health and education must be accounted as investment rather than expenditure in national account as it helps in human capital formation which in return immensely contributes to the economic growth. In this chapter we estimate the genuine saving of different states of India. Genuine saving reflects the sustainability better than net saving. Because it considers the changes in the natural resource base in the economy (Hamilton and Clemens, 1999). Hence, to adjust the savings with the value of natural resource extraction is essential. The crux of calculating genuine saving is to subtract the value of natural resource depletion (Hamilton, 2000). Pearce and Atkinson (1993) adjusted the conventional national accounts of twenty countries by the value of depletion and degradation of natural resources to get the true saving behavior of the economy. Augmented measure of saving is considered as the indicator of sustainable development by the World Bank (World Bank, 1997). Initial step of calculating genuine saving is the standard saving calculation as it is done in the conventional system. We use the following formula to calculate the genuine saving:

Genuine saving = Change in Capital Stock

- Depreciation of Physical Capital

- Value of Natural Resources Extracted

+ Expenditure on Health and Education (formation of human capital)

Change in capital stock is nothing but the gross fixed capital formation. Gross capital formation is defined as the aggregate of additions to fixed assets, increase in stock of inventories and valuables. Gross fixed capital formation is the total of construction and machinery and equipment (CSO, 2012). Depreciation of physical capital is the consumption of fixed capital. From the environmental perspective, it is not sufficient to deduct only the depreciation of physical capital. Due to human activities natural capital of the economy also gets depleted which must be deducted from gross fixed capital formation. In this study, value of mineral production is taken as the value of natural resources extraction as, here, we are trying to examine the sustainability of mining sector. Expenditure on health and education is the human capital which must be considered in the national saving of the economy. Spending on health and education at present shall bring the economic prosperity in future.

6.3.2 Data Sources

I have collected the gross fixed capital formation and depreciation of physical capital data from Handbook of Statistics on Indian States of various years published by RBI. Value of mineral production data is collected from EPWRF and Indian Minerals Yearbook. Expenditure on health and education data are collected from EPWRF. Expenditure data includes both capital and revenue expenditure. Depending upon the availability of data of all the variables needed to calculate the genuine saving we have considered the period from 2010-11 to 2018-19.

6.4 Analysis and Results

Value of genuine saving in an economy depends upon the volume of physical capital formation, depreciation of the physical capital, the value of natural resources extracted from the environment, and the value of human capital formation which is represented by the expenditure on health and education. The positive elements for the economy are physical and human capital formation. The negative components are depreciation of physical capital and natural capital which must be deducted in the calculation of national accounts.

Table 6.1a&b provide the genuine savings of different Indian states for the years 2010-11 to 2018-19. A positive value of genuine saving of a state indicates that the capital formation outweighs the loss of capital – both physical and natural - occurring in the form depreciation. Having negative value of genuine saving is a serious concern for the state to rethink about the use of different capitals available in the state. As we can see from the table 6.1a and b, during the initial period of the study years states such as Assam, Chhattisgarh, Goa, Jharkhand, Meghalaya, Rajasthan, and Telangana reported negative genuine saving. As the formula depicts, the value the net fixed capital formation and expenditure on health and education together is less than the capital loss in these states. But 2015-16 onwards these states have positive genuine saving even if net fixed capital formation of these states have declined. This transition from negative to positive genuine saving has happened due to drastic increase in the expenditure on health and education, as seen in the figure 6.1, during the phase of declining physical capital formation. The increase in health and education expenditure has outweighed the decrease in net fixed capital formation. Turning the negative genuine saving to positive in these states is also contributed by the dwindling mineral production value. Mineral production value representing the depreciation of natural capital of these seven states has declined (See figure 6.2).

Table 6.1a: Genuine Savings of Indian states (in lakh rupees)

State/ Year	2010-11	2011-12	2012-13	2013-14	2014-15
Andhra Pradesh	678522.35	618907.61	1066704.03	1308758.54	1889686.28
Arunachal Pradesh	-	-	-	-	164511
Assam	-314455.59	-155210.43	-297436.4	-66516.01	1274712.33
Bihar	1002065.21	1299267.19	1570883.35	1706838.93	1584439.44
Chhattisgarh	-457382.11	-404120.93	-445557.5	-147469.02	-222965.78
Goa	-631219.98	-557732.79	19516.09	127484.45	149433.05
Gujarat	1246289.23	1856535.65	2070755.87	4851071.13	8796396.17
Haryana	1186252.02	1184995.02	2726856.39	1276981.24	1549717.33
Himachal Pradesh	623375.08	705413.46	548730.42	370972.04	276836.15
Jammu and Kashmir	456968.35	540639.3	492326.19	564100.61	593099.93
Jharkhand	-304578.46	366985.42	-873907.83	-1752800.22	-1494213.9
Karnataka	2232482.41	3137368.75	2982586.15	2183597.59	2112656.92
Kerala	838257.64	963427.01	1446731.954	1961887.81	1821562.25
Madhya Pradesh	183921.79	499973.84	1017830.99	1376273.12	1473223.59
Maharashtra	3555576.25	4523322.82	5951941.04	6532967.9	6103786.36
Manipur	94106.34	110175.34	114389.34	130707.34	179654.34
Meghalaya	-135906.8	-315648.46	-228565.01	-256683.47	25345.43
Mizoram	76757.69	86900.01	102614.58	119639.17	147086.25

State/ Year	2010-11	2011-12	2012-13	2013-14	2014-15
Nagaland	97195.26	103336.26	122105.26	138154.26	149556.26
Odisha	307479.81	375297.63	700561.37	-329241.11	-1650224.8
Punjab	1059927.79	1122691.05	1135001.52	1098607.52	958041.52
Rajasthan	-277443.28	-290278.85	-776469.26	-746021.69	1028154.1
Sikkim	78917.13	76052.13	81920.13	91321.13	94205.13
Tamil Nadu	2244705.49	2811649.56	3031647.48	3416791.75	1539882.41
Telangana	NA	NA	-703085.82	-614625.94	-725902.44
Tripura	79866.82	91229.23	84390.47	98120.46	210423.71
Uttar Pradesh	2721763.47	3480710.79	4459697.9	3656972.94	4147257.15
Uttarakhand	774092.91	1050973.65	701729.31	625691.77	445897.57
West Bengal	1933969.67	1500449.48	1611983.49	2257873.58	1922370.55

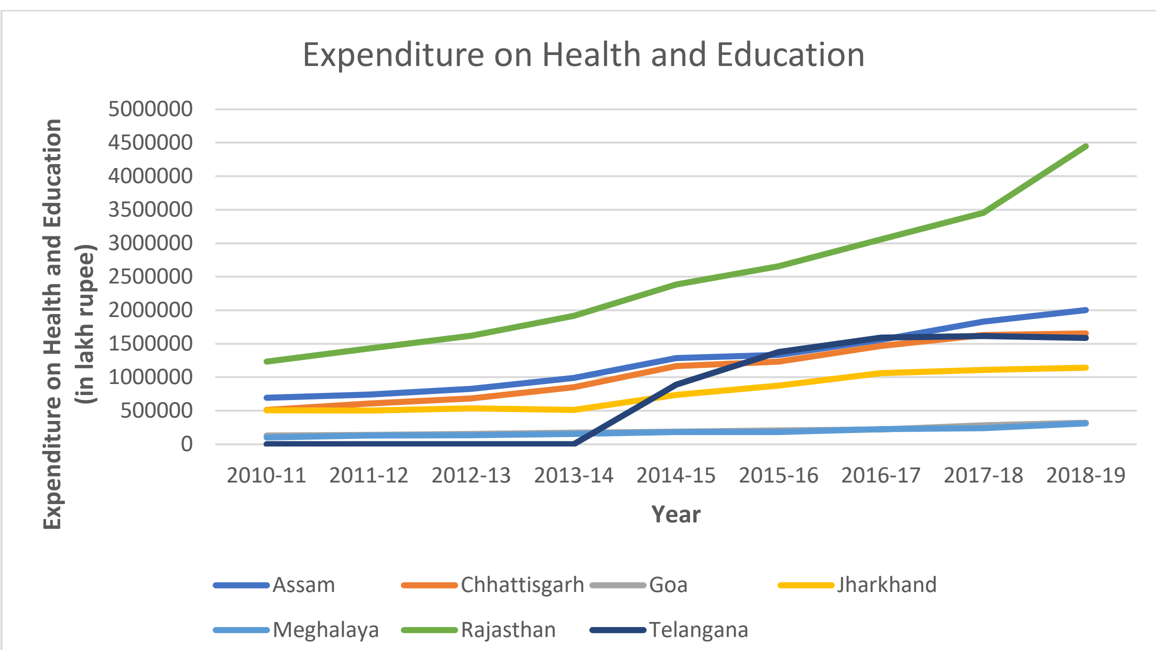
Table 6 .1b Genuine Savings of Indian states (in lakh rupees)

State/ Year	2015-16	2016-17	2017-18	2018-19
Andhra Pradesh	2579512.23	2360554	1083050.06	997608.6
Arunachal Pradesh	183725.91	216660.9	265779.91	306637.9
Assam	2211623.8	1587940	1800152.43	1993535
Bihar	1962053.28	2243036	2822196.83	3100343
Chhattisgarh	1354106.08	1415228	978096.07	857104
Goa	178963.23	127458.5	164100.53	358619.2
Gujarat	7224720.14	7964643	4500220.56	5205482
Haryana	1319539.3	1765448	1979039.99	2465744
Himachal Pradesh	276378.84	533902.5	641874.59	891735.5
Jammu and Kashmir	869679.12	867298.9	1031993.2	1488413
Jharkhand	1495924.46	829513.7	339421.03	300218.3
Karnataka	2719602.07	2719131	2626059.36	3338071
Kerala	2429119.3	2805104	2211154.3	2524547
Madhya Pradesh	2448486.64	2431970	2783554.16	3073123
Maharashtra	6077388.36	5797154	6760742.51	7949639
Manipur	159867.34	168206.3	191616.34	206047.3
Meghalaya	139136.67	211583.7	179533.97	258805.1

State/ Year	2015-16	2016-17	2017-18	2018-19
Mizoram	150213.07	154968.1	183047.07	201341.1
Nagaland	171528.26	177989.3	208408.26	242880.3
Odisha	794383.11	700595.8	-846776.66	-2731318
Punjab	1174643.52	1181155	1444374.2	1572546
Rajasthan	1256597.58	1443078	1811041.05	2504843
Sikkim	109665.13	179476.1	125329.13	89969.13
Tamil Nadu	4717870.02	4463769	4139206.2	4769339
Telangana	2044842.76	746056.2	1020845.28	924486.4
Tripura	220162.46	247445.1	314133.49	309684.5
Uttar Pradesh	5583856.18	6441373	5591331.63	6118471
Uttarakhand	871742.41	820985.2	786261.36	894635.5
West Bengal	2837071.87	3484668	3843518.87	3962698

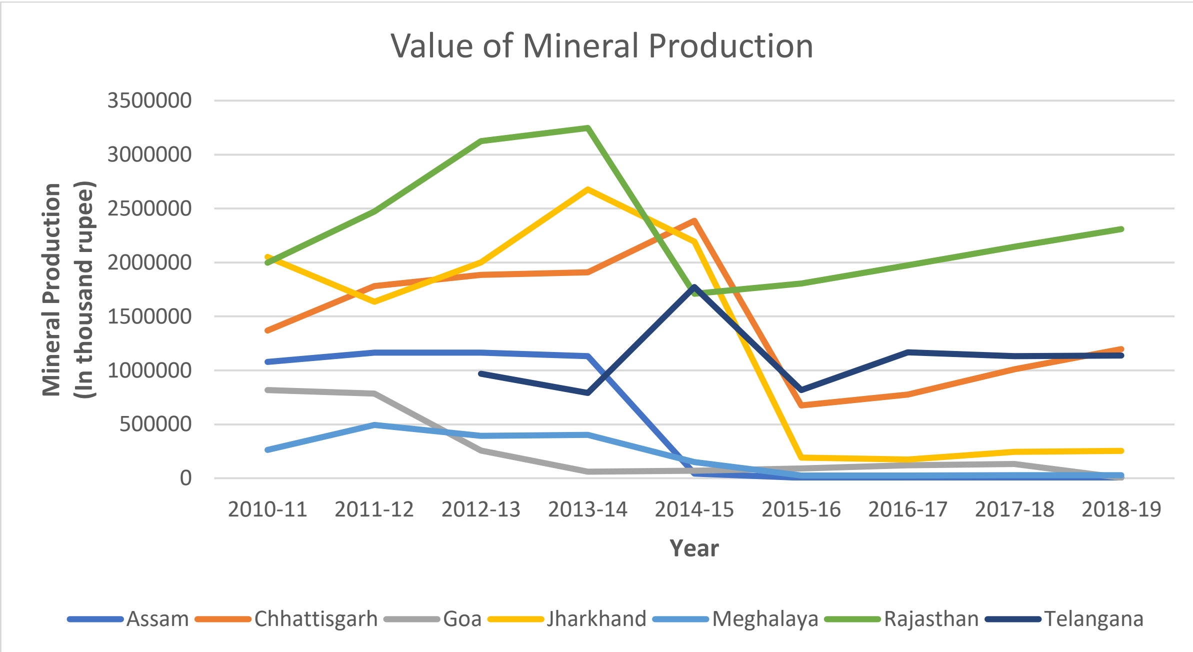
Sources: Author's calculation using data from Reserve Bank of India, EPWRF, Indian Minerals Yearbook, and Central Statistical Office (different years).

Figure 6.1 : Expenditure of selected Indian states on health and education



Source: Author's compilation from EPWRF data.

Figure 6.2: Value of mineral production of selected Indian states

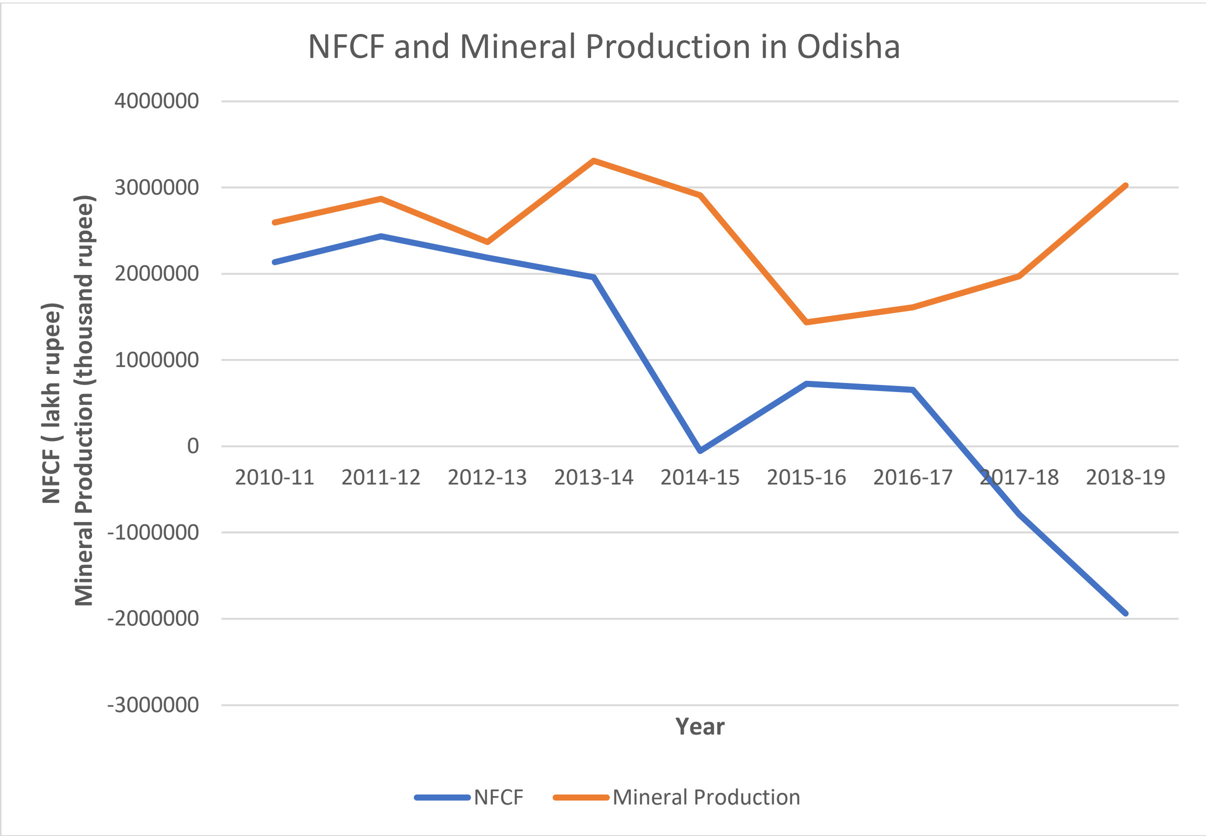


Sources: EPWRF and Indian Minerals Yearbook (different years)

Except Odisha all other states have reported positive genuine saving during the latest years taken into consideration in this research. States having negative savings in the initial years have been able to convert it into positive values. But Odisha experienced a positive genuine saving in the beginning is not able to sustain it throughout. It has negative saving in the years 2013-14 and 2014-15. It could make it positive after that. But again in 2017-18 it became negative. All other states have shown some level of consistency in maintaining positive or negative value of saving. The net fixed capital formation of Odisha state has declined drastically in the year 2013-14 and 2014-15. In the year 2014-15, the NFCF of the state is negative. Negative NFCF means the depreciation of physical capital has exceeded the gross fixed capital formation. Value of mineral production has also increased significantly in the year 2013-14. There is a 140per cent increase in the value of mineral production in this year. Throughout the period of 2010-11 to 2018-19, expenditure on health and education of the state has grown. But this rise in expenditure couldn't offset the negative

NFCF and expanding mineral production. During 2017-18 and 2018-19 also the state has large negative NFCF. In 2018-19, the rise in mineral production is about 65per cent. These factors have led to the negative genuine saving of the state.

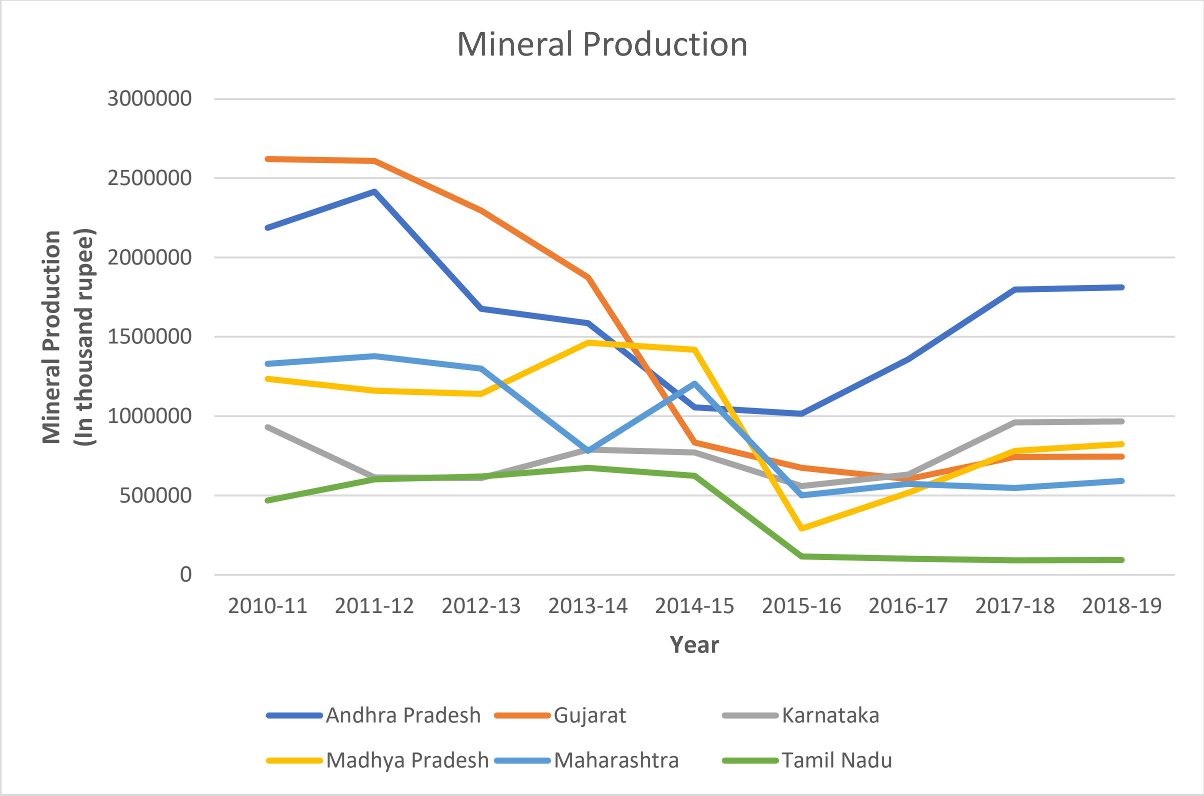
Figure 6.3: Net Fixed Capital Formation and Mineral Production of Odisha



Sources: Reserve Bank of India and EPWRF.

States such as Andhra Pradesh, Chhattisgarh, Goa, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, and Tamil Nadu are the mineral rich states of India. These states possess a number of major minerals like iron ore, coal, manganese ore, bauxite, etc. Out of these eleven mineral rich states, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, and Tamil Nadu never reported negative genuine savings. These states have never experienced negative NFCF between 2010-11 and 2018-19. Their expenditure on health and education have also increased. Value of mineral production of these states have gone down substantially (See figure 6.4).

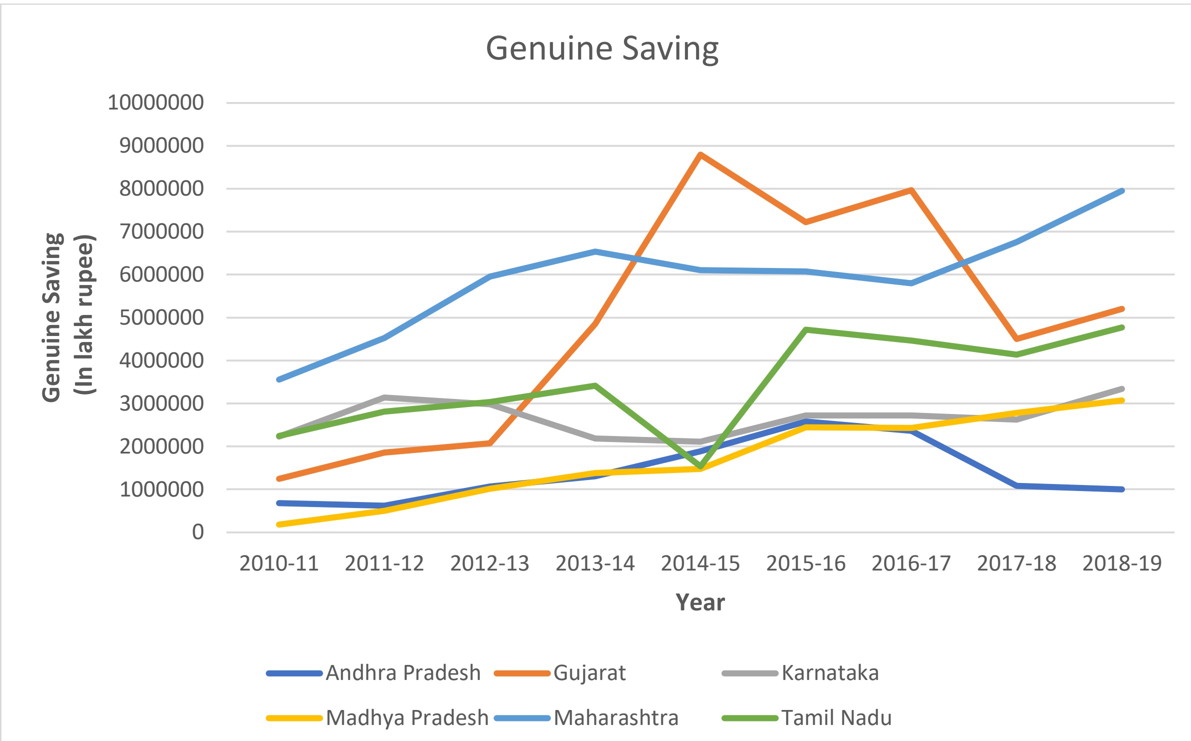
Figure 6.4: Value of Mineral Production of selected Indian States



Sources: EPWRF and Indian Minerals Yearbook.

The states which are not considered as mineral rich states have also performed well by having positive genuine saving throughout the period of our analysis except Assam, Meghalaya, and Telangana. Reduction in mineral production in Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, and Tamil Nadu has helped greatly in maintaining positive genuine savings. State like Kerala which is known for its investment in human capital and which is not a mineral rich state has surpassed, in generating genuine saving, so many mineral rich states such as Andhra Pradesh, Chhattisgarh, Goa, Jharkhand, Madhya Pradesh, Odisha and Rajasthan. We can infer that less production of minerals i.e. less extraction of mineral resources means future generation is less impacted and hence higher level of genuine savings(see figure 6.4 and 6.5).

Figure 6.5: Genuine Saving of selected India states



Sources: Author's calculation using data from Reserve Bank of India, EPWRF, Indian Minerals Yearbook, and Central Statistical Office.

Genuine saving reflects the sustainability of the economy. Positive genuine saving can be maintained by extracting mineral resources in a sustainable manner and increasing the investment on human capital formation i.e. through health, education, skill formation and research and development. As we can see from table 1, even the states which have miniscule amount of mineral resources are also having positive genuine saving. Investing on capital formation both physical and human is very much important for economic sustainability. In following sections we show the genuine saving as percentage of Gross State Domestic Product. We compare the expenditure on health and education with respect to mining state domestic product and royalty from minerals.

Table 6.2. : Genuine Saving of Indian states (as percentage of GSDP)

State/Year	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Andhra Pradesh	2	2	3	3	4	5	4	2	2
Arunachal Pradesh	-	-	-	-	11	13	15	17	18
Assam	-2	-1	-2	0	8	12	8	8	9
Bihar	4	5	6	6	6	7	7	8	8
Chhattisgarh	-3	-3	-3	-1	-1	7	7	5	4
Goa	-18	-13	1	4	4	4	2	3	6
Gujarat	2	3	3	7	11	8	8	4	4
Haryana	4	4	8	4	4	3	4	4	5
Himachal Pradesh	9	10	7	4	3	3	5	6	8
Jammu and Kashmir	6	7	6	7	7	9	9	10	13
Jharkhand	-2	2	-5	-11	-8	9	4	2	1
Karnataka	4	5	5	3	3	3	3	3	3
Kerala	2	3	4	5	4	5	6	4	5
Madhya Pradesh	1	2	3	4	4	6	5	6	6
Maharashtra	3	4	4	5	4	4	3	4	4
Manipur	8	9	9	9	12	10	10	10	11
Meghalaya	-8	-16	-11	-12	1	7	10	8	10
Mizoram	10	12	13	13	13	12	11	13	14
Nagaland	9	8	9	10	10	12	11	13	14
Odisha	1	2	3	-1	-6	3	2	-2	-7
Punjab	4	4	4	4	3	4	3	4	4
Rajasthan	-1	-1	-2	-2	2	2	2	3	4
Sikkim	8	7	7	8	7	8	12	7	5
Tamil Nadu	3	4	4	4	2	5	4	4	4
Telangana	-	-	-2	-2	-2	4	1	2	2
Tripura	4	5	4	4	8	8	8	9	8
Uttar Pradesh	4	5	6	5	5	6	6	5	5
Uttarakhand	7	9	6	5	3	6	5	4	5
West Bengal	4	3	3	4	3	5	5	6	5

Sources: Author's calculation using data from Reserve Bank of India, EPW_RF, Indian Minerals Yearbook, and Central Statistical Office.

Genuine saving as percentage of Gross State Domestic Product (GSDP) is presented in Table 6.2. The north-eastern states Assam, and other small states namely Arunachal Pradesh, Meghalaya, Mizoram, Manipur and Nagaland have higher genuine saving as percentage of GSDP. It varies from -16per cent for Meghalaya in 2011-12 to 18per cent for Arunachal Pradesh in 2018-19. In later period of the study Meghalaya's genuine saving has improved to 10per cent of GSDP. Tripura has also performed well as compared to other mainland states. All the north-eastern states other than Tripura have reported genuine saving more than 10per cent in some years. Overall the north-eastern states have performed well in genuine saving as percentage of GSDP as compared to other Indian states. This could be because of the small size of the economy. All north-eastern states except Assam have smaller GSDP compared to other Indian states. For understanding sustainability issue we need to compare the genuine saving of mineral rich states with other states.

Table 6.3a: Expenditure of Indian States on Health and Education / Mining SDP

Year	ANDHRA PRADESH	ARUNACHAL PRADESH	ASSAM	BIHAR	CHHATTISGARH	DELHI	GOA
2010-2011	1.15	3.43	0.49	54.31	0.27	0	0.20
2011-2012	1.36	4.53	0.51	60.62	0.31	0.95	0.22
2012-2013	1.46	3.17	0.61	76.36	0.35	1.19	0.75
2013-2014	1.71	3.29	0.79	12.45	0.41	1.06	54.36
2014-2015	1.66	4.87	1.01	34.23	0.55	1.09	61.45
2015-2016	1.20	4.35	0.54	13.06	0.61	1.14	5.67
2016-2017	1.09	3.65	0.64	19.64	0.67	1.46	1.33
2017-2018	1.23	5.13	0.69	94.21	0.69	1.54	1.89
2018-2019	1.27	6.75	0.66	43.83	0.65	1.41	49.54
2019-2020	1.70	6.81	0.74	11.23	0.83	1.42	48.84
2020-2021	1.55	13.66	1.38	88.19	1.27	1.67	57.32
2021-2022	1.50	0	0	85.93	0	1.70	0

Table 6.3b Expenditure of Indian States on Health and Education / Mining SDP

Year	GUJARAT	HARYANA	HIMACHAL PRADESH	JAMMU AND KASHMIR	JHARKHAND	KARNATAKA	KERALA
2010-2011	0.76	66.48	11.26	14.62	0.37	1.57	4.09
2011-2012	0.83	63.19	13.31	15.93	0.31	3.45	4.44
2012-2013	0.79	93.79	15.85	13.34	0.31	4.72	5.94
2013-2014	1.05	33.60	19.54	16.73	0.30	3.68	4.42
2014-2015	1.10	35.03	21.15	23.10	0.37	3.20	3.06
2015-2016	0.68	17.98	20.83	9.68	0.44	2.72	10.64
2016-2017	0.67	11.82	10.58	45.63	0.63	3.23	8.86
2017-2018	0.69	14.13	32.70	66.81	0.65	3.58	7.45
2018-2019	0.76	21.84	29.18	50.87	0.62	4.27	9.37
2019-2020	0.77	14.36	31.46	88.81	0.70	4.32	12.72
2020-2021	0.92	13.55	43.30	232.51	1.18	4.34	12.36
2021-2022	0	14.58	44.74	212.53	1.19	4.23	12.51

Among the mineral rich states Gujarat has performed better. In 2014-15, Gujarat reported 11per cent genuine saving. Odisha and Rajasthan are the worst performer in marinating the genuine saving as percentage of their GSDP. In the recent years genuine saving of Rajasthan has improved whereas Odisha has consistently performed poorly. Non mineral rich states like Himachal Pradesh, Jammu and Kashmir, Sikkim, Uttarakhand have performed at par with Gujarat. Other non-mineral states like Kerala, Punjab, Uttar Pradesh and Haryana have maintained genuine saving as par with the mineral rich states like Andhra Pradesh, Tamil Nadu and Karnataka.

Overall, most of the mineral rich states do not perform well in genuine saving as compared to the non-mineral states.

Table 6.3c Expenditure of Indian States on Health and Education / Mining SDP

Year	MADHYA PRADESH	MAHARASHTRA	MEGHALAYA	MIZORAM	NAGALAND	ODISHA	PUDUCHERRY	PUNJAB
2010-2011	0.92	0.59	0.80	19.96	17.34	0.28	0	88.96
2011-2012	1.05	0.62	0.95	17.17	18.38	0.30	3.22	186.91
2012-2013	1.04	0.68	1.17	26.94	31.93	0.34	2.42	429.96
2013-2014	1.39	1.03	0.94	10.20	19.67	0.33	3.80	110.51
2014-2015	1.79	0.89	2.73	19.22	19.36	0.46	3.75	120.07
2015-2016	1.85	0.87	1.63	22.04	9.17	0.41	3.67	339.75
2016-2017	2.05	0.89	2.77	39.37	41.57	0.40	3.00	270.89
2017-2018	2.00	0.90	3.29	21.65	40.33	0.50	2.34	241.88
2018-2019	2.11	0.92	9.33	14.95	27.85	0.53	2.76	254.26
2019-2020	2.79	1.13	9.62	13.88	9.87	0.59	3.04	233.52
2020-2021	2.76	1.17	11.13	39.39	12.09	0.73	3.64	310.23
2021-2022	2.63	0	9.30	0	0	0.77	3.36	318.50

Table 6.3d Expenditure of Indian States on Health and Education / Mining SDP

Year	RAJASTHAN	SIKKIM	TAMIL NADU	TELANGANA	TRIPURA	UTTAR PRADESH	UTTARAKHAND	WEST BENGAL
2010-2011	0.81	135.32	6.07	0.00	1.02	2.86	2.28	2.72
2011-2012	0.78	95.50	5.92	0.00	1.19	4.84	2.31	2.69
2012-2013	0.50	96.18	7.63	0.00	1.14	5.58	2.67	2.62
2013-2014	0.55	86.47	9.29	0.00	1.33	5.45	1.79	3.39
2014-2015	0.59	91.61	13.22	0.71	0.59	4.73	3.00	3.41
2015-2016	0.51	80.99	8.10	0.98	0.64	4.55	3.41	3.73
2016-2017	0.52	83.86	7.40	1.05	0.67	4.90	2.81	4.34
2017-2018	0.58	108.94	7.74	0.92	0.87	2.14	2.51	4.08
2018-2019	2.08	130.88	8.05	0.71	0.74	2.32	3.02	3.93
2019-2020	2.44	188.29	10.47	0.90	0.84	3.73	3.53	4.25
2020-2021	2.71	285.70	15.51	1.00	1.11	3.30	6.03	4.70
2021-2022	3.01	276.77	15.50	0.95	1.10	3.59	6.25	o

Source: EPWRF and Indian Minerals Yearbook.

Table 6.4a Expenditure of selected states on Health and Education / Royalty from minerals

State/year	2010-2011	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016
Andhra Pradesh	42.03	43.06	40.44	48.53	63.21	97.63
Assam	3823.19	3975.10	8211.30	22115.20	9217.88	4476.49
Bihar	NA	NA	NA	13466.52	18415.60	6365.51
Chhattisgarh	4.29	4.51	5.63	7.42	7.51	11.50
Goa	1.36	1.51	4.71	47.53	38.37	26.40
Gujarat	72.35	68.75	67.17	57.53	53.90	71.79
Himachal Pradesh	NA	NA	NA	71.40	54.78	73.92
Jammu & Kashmir	NA	NA	NA	656.24	526.80	679.62
Jharkhand	11.51	7.82	7.70	8.18	8.89	7.46
Karnataka	19.33	43.98	125.98	27.70	25.49	30.35
Kerala	931.79	1083.14	1102.39	1225.91	1217.47	1408.49
Madhya Pradesh	32.22	32.57	37.74	46.23	44.71	58.29
Maharashtra	235.44	256.05	275.64	267.98	341.30	322.30
Meghalaya	79.20	NA	NA	62.92	83.54	61.68
Odisha	3.50	2.49	2.18	2.71	3.81	4.42
Rajasthan	10.31	10.98	11.06	12.05	12.11	14.24
Tamil Nadu	120.80	87.65	NA	157.51	168.47	172.31
Telangana	NA	NA	NA	NA	45.11	72.50

Gross domestic product is the value of goods and services produced during a financial year. GDP figure plays an important role in deciding the budget expenditure. While comparing expenditure on different sectors in different economies, it is always analyzed with respect to the share in GDP. Health and Education sectors are two important sectors which should be given emphasis by all the countries specially the developing ones. Better health and education system in the country help in human capital formation which in turn contributes to economic growth. So it is very much important to keep track of how much we are spending on these key sectors. Table 6.3 –a,b,c and d provide the ratio of health and education expenditure to the state domestic product from the mining sector. If the value is greater than one it means the state is spending on health and education more than what it is getting from the mining sector. If the value is less than one it indicates that the state is spending some part of the mining SDP on education and health. States spending less than mining SDP on education and health in most of the years in consideration are Assam, Chhattisgarh, Gujarat, Jharkhand, Maharashtra, Odisha, Rajasthan, and Telangana. Out of these eight states, six states are mineral rich states. We have seen in the previous section that Gujarat is doing well in maintaining genuine saving, but it is not spending on health and education as much it is getting from the mining sector. So there is a scope to increase the spending on health and education. Chhattisgarh, Jharkhand, and Odisha are worst performer in terms of spending in health and education as share of mining SDP.

Table 6.4b Expenditure of selected states on Health and Education / Royalty from minerals

State/year	2016 - 2017	2017 - 2018	2018 - 2019	2019 - 2020	2020 - 2021
Andhra Pradesh	66.71	73.65	59.75	88.94	91.77
Assam	2953.31	3941.76	3977.13	2955.89	5411.18
Bihar	16635.47	19910.09	5883.29	NA	NA
Chhattisgarh	13.17	9.86	7.47	9.48	10.33
Goa	7.08	11.75	144.96	636.04	60.37
Gujarat	97.52	111.60	122.62	141.18	135.02
Himachal Pradesh	94.84	58.49	NA	80.65	106.27
Jammu & Kashmir	958.85	698.02	1633.87	2039.26	1646.02
Jharkhand	15.38	8.84	9.82	11.37	16.78
Karnataka	26.54	23.55	25.90	25.35	NA
Kerala	3547.55	2931.80	4854.56	2981.18	NA
Madhya Pradesh	72.63	67.99	63.78	85.97	85.72
Maharashtra	380.78	349.56	323.25	388.51	506.67
Meghalaya	50.72	42.82	36.02	NA	NA
Orissa	6.64	5.51	2.95	3.03	3.85
Rajasthan	12.93	13.04	15.29	17.31	16.57
Tamil Nadu	167.13	249.56	NA	NA	NA
Telangana	78.97	70.50	67.35	80.64	80.96

Sources: Annual Reports, Ministry of Mines, Govt. of India and EPW_RF.

State expenditure on health and education depends on the revenue collection. In India no systematic data are available on how much revenue the states are earning form mining sector.

Under-reporting, of mineral production and actual sale prices leads to low revenue collection by the state governments. In table 6. 4a and 6.4b I present the ratio of expenditure on health and education to the royalty collected from major mineral production in different states of the country. We calculate the ratio from 2010-11 to 2020-21 for selected states depending on the availability of data. The ratio depicts how much of revenue is spent on health and education. It is clear from the table that all states are spending more than the revenue collected from minerals. This revenue does not include the revenue from collected from coal, lignite, sand and other minor minerals. Among the mineral rich states Odisha, Chhattisgarh and Jharkhand are the worst performers. If we include the revenue from other minerals the performance of these states would be even worse. Kerala and Assam are the top performers among the non-mineral states.

Table 6.5a Expenditure of Indian states on Health and Education as percent of GSDP

Year	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016
ANDHRA PRADESH	4.50	5.09	5.50	5.82	4.77	4.18
ASSAM	5.06	5.19	5.63	6.42	7.79	6.98
BIHAR	4.31	4.87	6.43	6.40	7.07	7.88
CHHATTISGARH	3.43	3.84	4.11	4.66	6.29	6.48
GOA	3.69	3.35	4.31	5.50	4.63	4.46
GUJARAT	2.43	2.49	2.66	2.74	2.89	2.85
HIMACHAL PRADESH	1.32	5.24	5.77	5.71	5.99	5.78
JAMMU AND KASHMIR	6.64	6.70	6.70	7.05	7.56	9.35
JHARKHAND	6.97	3.35	3.29	3.10	3.95	5.00
KARNATAKA	9.48	2.56	2.85	2.89	3.15	2.96
KERALA	1.50	3.32	3.51	3.77	4.03	4.19
MADHYA PRADESH	3.04	3.88	3.98	4.63	5.44	5.47
MAHARASHTRA	1.75	2.73	2.93	3.11	3.12	3.16
MEGHALAYA	0.08	6.62	6.55	7.48	9.12	8.96
ODISHA	3.45	3.50	3.64	3.84	4.84	5.16
RAJASTHAN	3.07	3.28	3.57	3.94	4.57	4.72
TAMIL NADU	2.51	2.58	2.81	3.10	3.41	3.34
TELANGANA	0.00	0.00	0.00	0.00	2.13	2.97

Table 6.5a and 6.5b present the expenditure of Indian states on health and education as percentage of GSDP. In the year 2020-21 Assam, Bihar, Jammu and Kashmir and Meghalaya have spent more than 10per cent of their GSDP on education and Health. These states have also shown higher expenditure as compared to the mineral revenue collected except Meghalaya (see table 6.4a and 6.4b). Comparatively, Kerala's spending on health and education as percentage of GSDP and as percentage of mineral revenue do not match become of very insignificant revenue collection from minerals. Sadly no mineral rich sate has reported expenditure on health and education more than 10per cent of GSDP. For all the states considered for our analysis the health and education expenditure as percentage of GSDP has increased from 2010-11 to 2020-21. Same is the case for the ratio of expenditure to mineral revenue.

Table 6.5b Expenditure of Indian states on Health and Education as percent of GSDP

Year	2016 - 2017	2017 - 2018	2018 - 2019	2019 - 2020	2020 - 2021
ANDHRA PRADESH	4.15	4.15	3.99	4.78	4.67
ASSAM	7.72	8.32	8.66	8.72	11.18
BIHAR	7.93	8.85	9.09	8.37	12.64
CHHATTISGARH	6.87	7.40	6.95	8.29	9.76
GOA	4.35	5.35	6.09	5.92	8.31
GUJARAT	2.69	2.71	2.80	2.60	2.91
HIMACHAL PRADESH	6.52	7.04	6.93	6.86	9.29
JAMMU AND KASHMIR	9.05	10.11	13.18	12.01	18.77
JHARKHAND	5.50	5.27	4.99	5.67	8.23
KARNATAKA	2.91	2.94	3.07	3.14	3.46
KERALA	4.71	4.83	4.69	4.55	5.48
MADHYA PRADESH	5.83	6.31	6.33	6.83	7.31
MAHARASHTRA	3.07	3.17	3.21	3.73	4.45
MEGHALAYA	10.43	10.61	13.12	11.34	17.07
ODISHA	4.91	5.29	5.78	5.97	6.79
RAJASTHAN	5.13	5.50	6.92	6.33	7.25
TAMIL NADU	3.26	3.34	3.57	3.87	4.37
TELANGANA	3.13	2.90	2.61	2.61	2.60

Source: EPWRF and Central Statistical Office, India.

6.5 Conclusion

In the states of Assam, Chhattisgarh, Goa, Jharkhand, Meghalaya, Rajasthan, and Telangana the drastic increase in the expenditure on health and education has helped them in converting the negative genuine saving into positive. Reduction in mineral production in these states has also contributed to this transition. Except Odisha all other states have reported positive genuine saving during the latest years taken into consideration in this research. But Odisha which experienced a positive genuine saving in the beginning is not able to maintain it throughout. The net fixed capital formation of Odisha has declined drastically in the year 2013-14 and 2014-15. Out of eleven mineral rich states, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, and Tamil Nadu never reported negative genuine savings. State like Kerala which is known for its investment in human capital and which is not a mineral rich state has surpassed, in generating genuine saving, so many mineral rich states such as Andhra Pradesh, Chhattisgarh, Goa, Jharkhand, Madhya Pradesh, Odisha and Rajasthan.

Chapter 7

Summary, and Conclusion

7.1 The Problem

Sustainable use of non-renewable natural resources has been a significant concern for policymakers worldwide, particularly after the publication of the Brundtland Commission Report. Policy formulation for sustainable development called for necessary changes in the national accounts as the conventional accounting system ignores the impact of human activities on the environment. The contribution of ecosystem and environment needs to be accounted for (United Nations, 2014) in the conventional income metrics. Natural capital or environmental asset plays a crucial role in the country's development. Environmental assets constitute a significant part of the productive base of the economy. According to United Nations (2014), there are seven components of environmental assets. These are (1) Mineral and energy resources, (2) Land, (3) Soil resources, (4) Timber resources, (5) Aquatic resources, (6) Other biological resources, and (7) Water resources. To measure the inclusive wealth of the economy, these assets should be valued in monetary terms. Inclusive wealth comprises of the value of produced, natural, and human capital. Intergenerational well-being is dependent on inclusive wealth (Dasgupta, 2021). Measurement of the value of the stock of resources is one way of doing environmental accounting. The other way is to internalize the negative impacts of extraction of natural resources in the accounting process. Keeping in mind the dearth of research in green national account of mining sector in India and the growing demand for research on sustainable development, this study tried to (1) construct the physical and monetary asset accounts of mineral resources in India, (2) adjust the conventional national account with the value of depletion cost and pollution cost from coal mining in India, and (3) discuss the sustainability of mining sector in different states of India.

7.2 Summary of Findings of the Study

This study focused on the mining sector of Indian economy. Before discussing the accounting of mineral resources, I have briefly discussed the development of environmental accounting in India in chapter 2. It highlighted the current state of green accounting in India. Individual researchers have started working on environmental accounting in India since the early 1990s. CSO has also attempted to work in this line since the 1990s. Though CSO, has initiated several studies on natural resource accounting, we are far away from measuring inclusive wealth and green GDP. It has been publishing Environmental Statistics on physical stocks of different natural resources. Valuation of all these resources is needed to calculate the wealth and to integrate the environmental aspects to economic accounting. India is also a part of the UN project called 'Natural Capital Accounting and Valuation of Ecosystem Services' (NCAVES) along with Brazil, China, Mexico, and South Africa. This can help the government of India significantly in the process of implementing SEEA (Padhan and Das, 2021).

In chapter 3, I have provided an economic profile of the mining sector. Contribution of mining sector to the output, employment and trade is discussed. India has been producing so many minerals and using them to meet the internal demand and also exporting to various countries in the world. The value of mineral production has gone up since independence. Among the mineral rich states Odisha contributes the most to the value of mineral production. GVA of M&Q sector has been increasing but its share to total GVA of the Indian economy has gone down since 1991-92. Total employment in mining has also declined since 1992 in spite of a substantial growth in the mineral production. Employment elasticity for most of the years after 1992 has been negative due to negative growth in employment in mining and quarrying sector. From 1992 to 2006, growth rate of employment is negative. Whereas for this period, growth rate of output has been positive for all the years. Growth of the mining sector has not contributed to the generation of employment in the economy during this period. I find a large gap between the number of the men and women working in the sector. Mining has always been male dominated sector. Negative trade balance of the mining sector is growing which is a serious concern for international trade in India.

Chapter 4 presents the physical and monetary asset accounts of mineral resources. The reserves of iron ore, manganese ore and bauxite in India have declined from 1995 to 2015. This poses serious questions on the sustainable use of resources and intra-generation equity. The future generation will be worse off with fewer mineral resources. In physical terms, production or extraction of all three minerals have increased significantly from 1995 to 2015. The extraction rate of bauxite has been much higher than iron ore and manganese ore. Though all the minerals gave negative resource rents to the economy in 1995, they turned positive in the subsequent years. Resource rents have increased remarkably. Because of negative resource rent in 1995, the NPV of all minerals was negative in 1995. Overall, the NPV of the resources has risen from 1995 to 2015 barring a slow down during 2005 to 2010. The substantial rise in the NPV and resource rent of all three minerals after 2010 can be explained by the drastic rise in the prices of minerals driven by global demand.

Chapter 5 provides the environmental adjusted GVA of mining and quarrying. The depletion or User's cost of coal mining is zero in all the years from 2004 to 2015. It is because the life index of coal reserves for all the years is very high, varying from 503 to 680. However, the life index is declining throughout the years in consideration. This trend implies that we need to be careful in using coal resources. The total methane emission from coal production has increased from 2004 to 2015. This is because of the rising volume of coal output in both surface and underground mines.

Methane emission from surface mining has a significant share of the total emission. The environmental cost as percentage of GVA varies from 4.5 per cent to 3 per cent. This environmental cost includes only the pollution cost of mining. From 2004 to 2015 the environmental cost of production of per ton of coal has increased significantly.

In Chapter 6, I have calculated the genuine saving of Indian states and discussed the sustainability of mining sector. In the states of Assam, Chhattisgarh, Goa, Jharkhand, Meghalaya, Rajasthan, and Telangana the drastic increase in the expenditure on health and education has helped in converting the negative genuine saving into positive. Reduction in mineral production in these states has also contributed to this transition. Except Odisha all other states have reported positive genuine saving during the latest years taken into consideration in this research. But Odisha which experienced a positive genuine saving in the beginning is not able to maintain it throughout. The net fixed capital formation of Odisha state has declined drastically in the year 2013-14 and 2014-15. Out of eleven mineral rich states, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, and Tamil Nadu never reported negative genuine savings. States like Kerala which is known for its investment in human capital and which is not a mineral rich state has surpassed, in generating genuine saving, so many mineral rich states such as Andhra Pradesh, Chhattisgarh, Goa, Jharkhand, Madhya Pradesh, Odisha and Rajasthan.

7.3 Policy Implications

In this study I attempted to (1) present the physical and monetary asset account of manganese ore, iron ore and bauxite, (2) calculate the environmentally adjusted GVA from coal mining (3) discuss the sustainability of mining sector in states of India. Policy implications of this study should be viewed from the accounting framework where an inclusive accounting system tries to include as much information as possible. Because for the study all the mineral resources are not taken into consideration, policy implications should be considered for the particular minerals taken into consideration.

Target two of SDG 12 aims to achieve the sustainable management and efficient use of natural resources by 2030. In this context wealth accounting at the national and sub-national levels is crucial to achieving sustainable development and ensuring intra-generation equity. The net present value of a mineral is the wealth of minerals existing at a particular time. Wealth accounting using the NPV approach provides an idea of the existing wealth of a particular resource (The World Bank, 2006). It shows the path to extract the resources at different discount rates (United Nations, 2014). The gross Domestic Product figure does not reflect the future use of any resources. It only gives us the partial economic value generated from a particular resource without any environmental stock and valuation information. Economic policies made without having information on total wealth and the future path of use of resources will undoubtedly lead to an unsustainable economy. In this research, the wealth of the three minerals such as manganese ore, iron ore and bauxite has increased while having a declining phase in the reserves. Availability of these minerals is going to reduce for future generations, if new discoveries do not happen. Hence, government should invest more on research and development for the exploration of the minerals. As the wealth value of the resources have increased, we can say that we are using these minerals sustainably but this poses a serious problem for the case of strong sustainability where the natural capital is not substitutable.

Conventional economic cost of coal production includes compensation to employees, intermediate consumption, consumption of fixed capital, and return to produced capital. Central Statistical Office of India provides the data of these costs. But it does not have any data on environmental cost of mining. This clearly shows that the policy decisions taken on the basis of the economic costs alone are not compatible for sustainable development. I try to calculate a segment of environmental cost of coal production. From 2004 to 2015 the environmental cost of per tonne of coal production has increased significantly. The cess imposed on coal should reflect the environmental cost borne by the society. In the year 2010, the amount of cess levied on coal was Rs. 50 per tonne and the estimated environmental cost from methane emission alone was Rs.48.98. The environmental cost that we have calculated here is just one part of the several environmental aspects. If all the costs like water pollution, soil erosion, deforestation, etc are computed, the cess/tax would be much lower than the cost. We therefore suggest that the tax imposed on coal should be reflective of the environmental cost borne by the society. Therefore, comprehensive studies should be conducted to measure the total environmental cost and efforts should be made to collect the matching amount of environmental tax/cess.

Genuine saving is positively related with the human capital formation. Assuming the substitutability between the physical, human and natural capital, government should spend more money on health and education to maintain positive genuine saving. As we saw in chapter 6 that all mineral rich states are not necessarily having positive genuine saving, these states should be careful in spending the mineral revenues. Otherwise, there would be reduction in total capital base of the economy.

7.4 Limitations of the Study

Most of the limitations arise from the unavailability of data in mining sector. However, given the limited data I have tried to make sense of the research remaining within the accounting framework. Government of India collects the reserve data for minerals once in a five year. There are no continuous reserve data available for mineral resources. It is very difficult to construct the proper physical asset account following the SEEA framework as systematic data on reclassification, discoveries, reappraisal, and catastrophic loss data are not available. If these data were available we could have provided better understanding of the flow of the resources. I have presented the physical and monetary asset account of only three mineral resources in chapter 4. Researchers can try for other minerals. However, to calculate the wealth of the mining sector as a whole government of India should take initiative. As government agencies are producing the GVA/GDP data of mining sector, it should produce the data of wealth of all the mineral resources.

In this study, I have calculated only two costs of coal mining in India. These two costs are depletion cost and pollution cost. Method of pollution cost calculation is available only for coal production. That is why only coal sector is taken into consideration. Due to lack of systematic data in India other costs like soil erosion, water pollution, etc. costs are not measured. I have measured a part of the total cost and adjusted the conventional national account. Researchers and government agencies can develop methods to calculate the cost of mining for all the mineral resources. This may need large scale work and time and involvement of interdisciplinary expertise. But cost calculation is essential. It is necessary for the internalization of costs and policy formulation.

There is no uniformity in variables and the years of study across the chapters of the thesis. This is again because of the unavailability of the data. In chapter 4, I have taken the case of manganese ore, iron ore, and bauxite for the period of 1995 to 2015. Whereas for chapter 5 in the case of cost calculation I have taken the coal sector for the period of 2004 to 2015 and derived the cost for mining sector as a whole.

7.5 Issues for Further Research

Internalizing the environmental aspects in national accounts is essential to make these accounts inclusive and more informative. Particularly for the non-renewable resources, immediate initiatives should be taken by the government and non-government researchers and agencies as these resources are finite and can get extinct if not used properly. This work would encourage researchers to take up studies in mineral resources which are not included here.

To calculate the green accounts for the economy, we have to include all the sectors like we do in the case of calculation of conventional GDP. Mining and quarrying is a subsector in primary sector of the economy. To get a green GDP, all the three sectors should be adjusted with environmental costs and benefits. I hope my work would encourage researchers to extend the green accounting task to other sectors beyond mining and quarrying.

My work highlights the problem of unavailability of data and methods in estimating the environmental accounting of mineral resources. As a result of which I had to use indirect methods and some assumptions. Researchers, beyond the discipline of Economics, may take interest in developing the methods to estimate the environmental accounting for other mineral resources.

References:

Alves, C., Ferreira, P., and Araujo, M. (2020). Challenges and pathways for Brazilian mining Sustainaibility. *Resources Policy*, https://doi.org/10.1016/j.resourpol.2020.101648

Arrow, K.J., Dasgupta, P., Lawrence H. G., Kevin J. M., and Kirsten, O.(2010). Sustainability and the Measurement of Wealth. *National Bureau of Economic Research, Working Paper* 16599.

Atkinson,G.,Dietz,S.,Neumayer,E.,Agarwala,M.(2014).Introduction., in Atkinson, G., Dietz, S., Neumayer, E. (Eds.*), Handbook of sustainable development*, Edward Elgar Publishing: Cheltenham.

Aurelien, N., Hu, J., Ousmane, S., Makuza, B., and Pitiya, R. (2022). Impact of Mining Rights Allocation Process on the Sustainable Development of the Copper Mining Industry in Zambia. *Journal of Geoscience and Environment Protection*, vol. 10, 227-246.

Auty, M.R. (2003). *Natural Resources, Development Models and Sustainable Development*. Environmental Economics Programme, Discussion Paper 03-01.

Auty, R. and Warhurst, A. (1993). Sustainable Development in mineral exporting economies. *Resources Policy*, March.

Azapagic, A. (2004). Developing a framework for sustainable development indicators for the mining and minerals industry. *Journal of Cleaner Production*, vol. 12, 639-662.

Bartelmus, P. and Tongeren, J. V. (1994). *Environmental Accounting: an operational perspective* Working Paper Series No. I United Nations, New York: Department for Economic and Social Information and Policy Analysis.

Bui, N.T. et al. (2017). Proposal of an indicator based sustainability assessment framework for the mining sector of APEC economies. *Resources Policy*, Vol. 52, 405-417.

Bureau of Economic Analysis (1994). Accounting for Mineral Resources: Issues and BEA's Initial Estimates. *Survey of Current Business,* April, US Department of Commerce.

Cairns, R.D. (2004). Principles of green accounting for renewable and non-renewable energy resources. *Energy Policy*, Vol.32, 261-267.

Cairns, R.D. (2006). On accounting for sustainable development and accounting for the environment. *Resources Policy*, Vol. 31, 211-216.

Cairns, R.D. (2009). Green Accounting for Black Gold. *The Energy Journal*, Vol. 30, No. 4, 113-139.

Cardoso, A. (2015). Behind the life cycle of coal: Socio-environmental liabilities of coal mining in Cesar, Colombia. *Ecological Economics*, Vol. 120, 71-82.

Castano, A., Lufin, M., and Atienza, M. (2019). A structural path analysis of Chilean mining linkages between 1995 and 2011. What are the channels through which extractive activity affects the economy? *Resources Policy*, Vol. 60, 106-117.

Castano, A., Lufin, M., and Atienza, M. (2019).A structural path analysis of Chilean mining linkages between 1995 and 2011. What are the channels through which extractive activity affects the economy? *Resources Policy*, 60, 106-117.

CMDR (2008). *Natural Resource Accounting in Karnataka: A study of the Land and Forestry Sector (Excluding Mining).* MOSPI, Govt. of India.

Common, M. and Sanyal, K. (1998).Measuring the depreciation of Australia's non-renewable resources: a cautionary tale. *Ecological Economics*, Vol 26, pp 23-30.

CSO (2012).*National Accounts Statistics: Sources and Methods 2012*.MOSPI, Govt. of Indi. http://mospi.nic.in/sites/default/files/publication_reports/sources_method_2012%20(1).pdf

CSO (2018). *EnviStats-India 2018*. Central Statistics Office, Ministry of Statistics &Programme Implementation, Government of India, New Delhi.

CSO (2018).EnviStats-India 2018. Central Statistics Office, Ministry of Statistics &Programme Implementation, Government of India, New Delhi

CSO (2019-1). *EnviStats-India 2019, Vol.I: Environment*. Statistics, Central Statistics Office, Ministry of Statistics &Programme Implementation, Government of India, New Delhi.

CSO (2019-2): *EnviStats India 2019 (Vol II: Environment Accounts)*, Ministry of Statistics and Programme Implementation, Government of India, New Delhi.

Daly, H.E. (1989). Toward a measure of sustainable net national product. In *Environmental Accounting for Sustainable Development,* A UNEP-World Bank Symposium, eds. Y.J. Ahmad, S.El. Serafy and E. Lutz, 8-9.

Das, A. (2014) *Performance of Public and Private Mining Firms in India: In Productivity, Environmental and Social Dimensions*. Cambridge Scholars Publishing.

Das, A., and Acharya, S.(2016). Mining and Odisha's Economy. In Pulin B. Nayak, Santosh C. Panda and Prasanta K. Pattanaik (Eds.), *The Economy of Odisha: A Profile.* New Delhi: Oxford University Press.

Das, A., Padhan, D., and Sahoo, C. (2021).Depreciation of Capital due to Natural Disaster and Adjusted Net Domestic Product. *Disaster and Development*, Vol. 10, Issue No.01, January to June.

Dasgupta, P. (2012).National Wealth. *Population and Development Review*, Vol 38, 243-264.

Dasgupta, P. (2012a).Inclusive National Accounts: Introduction. *SANDEE, Working Paper*, No 67-12.

Dasgupta, P. (2012b).National Wealth. *Population and Development Review*, Vol 38, 243-264.

Dasgupta, P. (2013). The Nature of Economic Development and the Economic Development of Nature. *Economic and Political Weekly*, Vol 48, No 51, 38-51.

Dasgupta, P. (2021). *The Economics of Biodiversity: The Dasgupta Review*. (London: HM Treasury).

Davis, G.A., and Moore, D.J. (2000). Valuing mineral stock and depletion in green national income accounts. *Environment and Development Economics*, Vol. 5, 109-127.

Department of Environmental Affairs, Botswana (2007). *Towards mineral account for Botswana*.

Dialga, I. (2017). A sustainability index of mining countries. *Journal of Cleaner Production,* doi: 10.1016/j.jclepro.2017.12.185.

Eggert, R.G. (2001). *Mining and Economic Sustainability: National Economies and Local Communities*. International Institute for Environment and Development, No. 19.

El Serafy, S. (1989).The proper calculation of income from depletable resources.In Ahmad, Y.J., El Sarfy S. and E.Lurtz (eds*) Environmental Accounting for Sustainable Development*, Washington D.C., World Bank.

Epstein, M.J. (1996). Improving Environmental Management with Full Environmental Cost Accounting*. Environmental Quality Management,* Autumn, 11-22.

Epstien, P.R., et.al. (2011). Full cost accounting for the life cycle of coal. *Ecological Economics Reviews, Annals of the New York Academy of Sciences*, 1219, 73-98.

Esteves, A.M. (2008). Mining and social development: refocusing community investment using multi-criteria decision analysis. *Resources policy*, vol. 33, 39-47.

Eugenio, F. (2002). Green national accounting: the case of Chile's mining sector. *Environment and Development Economics* , 215 -239.

Eurostat (2003). *Subsoil asset accounts for oil and gas – Guidelines for the set of standard tables.* Statistical office of the European Communities.

Famiyeh, S., Opuko, A.R., Kwarteng, A., Darko, D.A. (2020). *Driving forces of sustainability in the mining industry: Evidence from a developing country.*

Figuerao, B.E., Orihuela, R.C., and Calfucura, T.E. (2010). Green accounting and sustainability of the Peruvian metal mining sector. *Resources policy*, vol. 35, 156-167.

Figueroa, B.E., Orihuela, R.C., and Calfucura, T. E. (2010). Green accounting and sustainability of the Peruvian metal mining sector. *Resources Policy*, Vol. 35, 156-167.

Galos, K., Niec, M., Saluga, P.W., and Uberman, R. (2015). The basic problem of mineral resources valuation methodologies within the Framework of System of Integrated Environmental and Economic Accounts. *gospodarka surowcami mineralnymi – mineral resources management*, Vol. 31, Issue 4, 5-20.

Ghorbani, Y. and Kuan, S.H. (2016). A review of sustainable development in the Chilean mining industry: past, present and future. *International Journal of Mining, Reclamation and Environment*, http://dx.doi.org/10.1080/17480930.2015.1128799

Gundimeda, H. Sanjeev, S., Sinha, R., and Sukhdev, P. (2005a). *Estimating the value of Agricultural Cropland and Pastureland in India.* Monograph, TERI Press: New Delhi.

Gundimeda, H. Sanjeev, S., Sinha, R., and Sukhdev, P. (2005b). *The value of timber, carbon, fuelwood, and non-timber forest products in India.* Monograph, TERI Press: New Delhi.

Gundimeda, H. Sanjeev, S., Sinha, R., and Sukhdev, P. (2006). *The value of biodiversity in India's Forests.* Monograph, TERI Press: New Delhi.

Gundimeda, H. Sanjeev, S., Sinha, R., and Sukhdev, P. (2007). Natural resource accounting for Indian states—illustrating the case of forest resources. *ECOLOGICAL ECONOMICS* 61 pp. 635–649. doi:10.1016/j.ecolecon.2006.07.035

Hamilton, K., and Clemens, M. (1999). Genuine saving rates in developing countries. *The World Bank Economic Review*, Vol.13, No.2, 333-356.

Harris, D., and Rieber, M. (1996). Commentary and Critique of "Accounting for Mineral Resources: Issues and BEA's Initial Estimates". *Nonrenewable Resources*, Vol.5, No.1, 7-21.

Harrison, A. (1989) Introducing natural capital into the SNA. In Ahmad, Y.J., El Sarfy S. and E.Lurtz (eds.*) Environmental accounting for sustainable development*, Washington D.C., World Bank.

Hartwick, J.M. (1977). Intergenerational Equity and the Investing of Rents from Exhaustible Resources. *The American Economic Review*, Vol. 67, No.5, 972-974.

Hartwick, J.M. (1990). Natural resources, national accounting and economic depreciation. *Journal of Public Economics* 43, 291–304.

Hilson, J. (2000). Sustainable development policies in Canada's mining sector: an Preview of government and industry efforts. *Environmental Science and Policy*, vol. 3, 201-211.

Hota, P. and Behera, B. (2016).Opencast Coal Mining and Sustainable Local Livelihoods in Odisha, India. *Miner Econ,* issue 29, 1-13.

Huang, G., Zhou, W., and Ali, S. (2011).Spatial patterns and economic contributions of mining and tourism in biodiversity hotspots: A case study in China. *Ecological Economics,* 70, 1492-1498.

Hueting, R. (1987).An economic scenario that gives top priority to saving the environment. *Ecological Modelling*, 38,123-140.

IEG (2006). *Natural Resource Accounts of Air and Water Pollution: Case Studies of Andhra Pradesh and Himachal Pradesh States of India,* CSO, Govt. of India.

IIFM (2006).*Natural Resource Accounting of Land and Forestry Sector (Excluding Mining) for the States of Madhya Pradesh and Himachal Pradesh*. MOSPI, Govt. of India.

IPCC (2019). 2019 refinement to the 2006 IPCC guidelines for national greenhouse gas inventories. https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

IPCC (2019). *2019 refinement to the 2006 IPCC guidelines for national greenhouse gas inventories.* https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

Jadavpur University (2008). *Natural Resource Accounting for West Bengal for the Sectors: Air and Water,* MOSPI, Govt. of India.

Kabir, M (2017). *Valuation of Subsoil Minerals: Application of SEEA for Bangladesh.* Working Paper No. 124-17, South Asian Network for Development and Environmental Economics (SANDEE).

Kadekodi, G. K.(2001).Environment and Development. in Bhattacharya R.N (Eds) *Environmental Economics: An Indian Perspective*,162-209, New Delhi: Oxford University Press.

Kumar, P., Sukhdev, P., Sinha, R., and Sanyal, S.(2006). *Accounting for the Ecological Services of India's Forests: Soil Conservation, Water Augmentation, and Flood Prevention,* Monograph, TERI Press: New Delhi.

Kumar, P., Sukhdev, P., Sinha, R., and Sanyal, S.(2007). *Accounting for freshwater quality in India.* Monograph, TERI Press: New Delhi.

Lange, G.M. (2002*). Sustainable Development in Mineral Economies: The Example of Botswana*. CEEPA: University of Pretoria.

Lange, G.M. (2013). Natural Capital, Total Wealth and Sustainable Development in Namibia. In R.M. Hassan & E.D. Mungatana (Eds.), *Implementing Environmental Accounts: Case Studies from Eastern and Southern Africa* (pp. 1-24). New York, London: Springer Press.

Lins, C. and Horwitz, E. (2007). *Sustainability in the Mining Sector*. FBDS, Rio de Janeiro.

Maler, K.G. (1991). National Accounts and Environmental Resources. *Environmental and Resource Economics*, 1(1), 1-15.

Malhotra, S. (2020). *Discounting the Climate Future: Social Discount Rate for India's Climate Policy.* The Energy and Resource Institute. https://www.teriin.org/sites/default/files/2020-11/policy-brief_discounting-climate-future_options.pdf

Martinez-Alier, J. (2001). Mining conflicts, environmental justice and valuation. *Journal of Hazardous Materials,* Vol. 86, 153-170.

McMahon, G., and Moreira, S. (2014), *The contribution of the mining sector to socio-economic and human development.* World Bank, Working Paper 87298.

MoEFCC (2015). *India First Biennial Update Report to the United Nations Framework Convention on Climate Change*. Ministry of Environment, Forests and Climate Change. Government of India.

Muller, N.Z., Mendelshon, R., and Nardhaus, W. (2011). Environmental accounting for pollution in the United States Economy. *American Economic Review*, Vol. 101, No. 5, 1649-1675.

Murty, M.N. (2001). Environmental Regulations and the Economics of Environmental Policies. in Bhattacharya R.N (Eds.) *Environmental Economics: An Indian Perspective*, 79-119, New Delhi: Oxford University Press.

NEHU (2008), *Environmental Accounting of Natural Resources of Meghalaya: Phase-I land and Forest Resources*, MOSPI, Govt. of India.

Nordhaus, W.D., and Kokkelenberg, E.C. (1999). *Nature's Numbers: Expanding the National Economic Accounts to Include the Environment*. Washington D.C.: National Academy Press.

NSO (2013). *Green National Accounts in India: A Framework.* MOSPI, Govt. of India, http://www.mospi.gov.in/sites/default/files/publication_reports/Green_National_Accouts_in_ India_1may13.pdf

Padhan, D. and Das, A.(2021). Environmental Accounting in India: Progress and Challenges. *Economic and Political Weekly*, Vol. LVI, Issue 31, 46-52.

Parikh, K.S., and Parikh, J.K. (1997). *Accounting and Valuation of Environment, Vol. I, A primer for Developing Countries.* New York: United Nations.

Pearce, D., and Atkinson, G.(1993). Capital theory and the measurement of sustainable development: an indicator of "weak" sustainability. *Ecological Economics*, vol.8, 103–108.

Petri, A. (2020). Clean energy cess-tax on coal. https://www.timesnownews.com/business-economy/industry/article/clean-energy-cess-tax-on-coal/683809

Ricke, K., Drouet, L., Caldeira, K., and Tavoni, M. (2018). Country-level social cost of carbon. *Nature Climate Change*, Vol. 8, 895-900.

Ryan, L., Thomson, R. & Sincock, A. (2003). *Accounting for subsoil assets in the Australian national accounts.* Australian Bureau of Statistics.

Santos, T. M and Zaratan, M.L. (1997). Mineral Resources Accounting: A Technique for Monitoring the Philippine Mining Industry for Sustainable Development. *Journal of Asian Earth Sciences*, Vol 15, No 23,155–60.

Sara, A. (2002). *Estimating the Value of Oil Capital in a Small Open Economy: the Venezuela example property rights, capital gains, and exploration costs in a country's oil capital,* Discussion paper Stockholm, Sweden : The Beijer Institute, The Royal Swedish Academy of Sciences.

Singh, A.K. and Kumar, J. (2016).Fugitive methane emissions from Indian coal mining and handling activities: estimates, mitigation, and opportunities for its utilization to generate clean energy. *Energy procedia*, 90,336-348.

Solow, R.M. (1974). Intergenerational Equity and Exhaustible Resources. *The Review of Economic Studies*. Vol. 41, Symposium on the Economics of Exhaustible Resources, 29-45.

Solow, R.M. (1986). On the Intergenerational Allocation of Natural Resources. *The Scandinavian Journal of Economics*, Vol. 88, No. 1, Growth and Distribution: Intergenerational Problems, 141-149.

Sopp, L.M. & Leiman, A. (2017). *Mineral Resource Accounting Measures in Africa.* Working Paper Series, No.283, African Development Bank Group.

Statistics New Zealand (2000). Mineral: *Monetary and Stock Account, 1994-2000.* Environmental Account Series.

Statistics South Africa (2002). *Natural Resource Accounting: Mineral Accounts for South Africa 1980-2000*. Discussion Document, July.

Statistics, South Africa (2012). *Mineral Accounts for South Africa: 1980-2009.* Statistics South Africa.

Stern, D.I. (1995). The Contribution of the mining sector to sustainability in developing countries. *Ecological Economics*, Vol. 13, 53-63.

Stern, N. (2006). *The Economics of Climate Change: The Stern Review.* Cambridge University Press.

TERI (2006). *Accounting for Unsustainable Mineral Extraction in Madhya Pradesh and West Bengal*, CSO, Govt. of India.

The Brundtland Commission (1987). *Our Common Future.* United Nations: Oxford University Press.

The World Bank (2006). *Where is the Wealth of Nations? Measuring Capital for the 21st Century*. The World Bank, Washington, DC.

Turner, P., and Tschirhart, J. (1999), Green accounting and the welfare gap. *Ecological Economics*, Vol. 30, 161-175.

Uberman, R. (2014). Valuation of Mineral Resources in Selected Financial and Accounting Systems. *Natural Resources*, Vol. 5, 496-506.

United Nations (1998). Basic problem of improving the capacity of developing countries and economies in transition to capture the maximum economic and social benefits of their potential for mineral production. In: *Report of the Secretary-General to Economic and Social Council Committee on Natural Resources, Fourth Session*, March, 10–19. https://digitallibrary.un.org/record/250739?ln=es

United Nations (2014).*System of Environmental-Economic Accounting 2012_ Central Framework*, New York.

Weitzman, M. L. (1976). On the welfare significance of national product in a dynamic economy. *Quarterly Journal of Economics* 90(1), 156-162.

World Bank Group (2018), *The Changing Wealth of Nations 2018: Building a Sustainable Future*. The World Bank, Washington, DC.

Xu, L., Bing Y., and Yue, W. (2010). A Method of Green GDP Accounting Based on Eco-services and a Case Study of Wuyishan, China. *Procedia Environmental Sciences*, Vol 2, 1865–72, https://doi.org/10.1016/j.proenv. 2010.10.198.

Yamaguchi, R. (2021). Genuine Savings and Sustainability with resource Diffusion. *Environmental and Resource Economics*, Vol. 80, 451-471.

Ying, Z., Minxue, G., Junchang L., Yali, W., and Weimin S. (2011). Green accounting for forest and green policies in China - A pilot national assessment. *Forest Policy and Economics*,Vol 13, 513-519.

Zeng, L., He, P., and Shi, J. (2019). Problems and Countermeasures in Environmental Cost Accounting: A case study of China's coal industry. *E3S Web of Conferences*, 83, 01013.

Zhuang, J., Liang, Z., Lin, T., and Guzman, F.D, (2007). *Theory and Practice in the Choice of Social Discount Rate for Cost-Benefit Analysis.* Working Paper No.94, Asian Development Bank.