# A Study of Contribution of Goan Iron Ore Mining Industry

GMOEA:
Goa Mineral Ore Exporters' Association
Goa, (India)

NCAER

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# Preface

The Mining and Quarrying industry in Goa has witnessed phenomenal growth in the last few years. Being the second most important industry next to Tourism industry of Goa, its contribution to state GDP now exceeds 10 per cent at current prices. With iron ore industry accounting for 94% of the total mining and quarrying sector in the state, the sudden increase of iron ore prices in the international markets explains the tremendous growth of the state's Mining and Quarrying industry.

The "wholly exported" iron ore industry contributes significantly to the exports, employment and foreign exchange earnings of Goa. In addition, it generates a substantial output multiplier and value added multiplier for the state. However, in the recent years, the operation of Iron ore industry in Goa has been under strict watch from the environmental perspective. The state Government has felt the need to implement certain policy measures, which poses difficult challenges to the mining operations.

NCAER was approached to carry out a comprehensive and analytical review of the iron ore mining industry of Goa and to assess the contribution of this industry to the economic development of Goa. This study was carried out using a social cost benefit analysis to analyse the social benefits obtained from the iron ore industry and to evaluate the pollution abatement costs associated with this industry. The study provides a comparison of the opportunity cost of not having the Iron Ore Mining Industry in terms of its contribution to state GDP, employment generation and present value of net benefits with the social costs of pollution and deforestation due to this industry. The report also gives a brief account of the actions taken by the mining industry of Goa towards addressing the safety concerns and protection of the environment.

It is hoped that this study would be valuable to discussions on the policies in the sector not only in Goa but also in the other states.

New Delhi
June 2010

Suman Bery
Director-General

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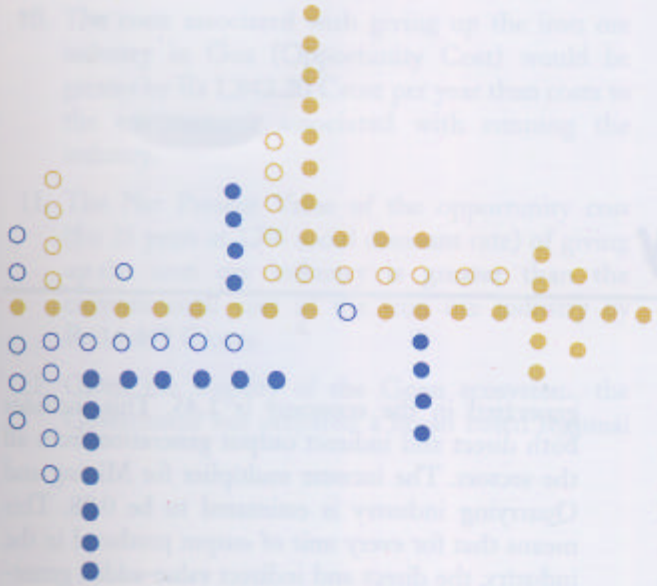


# Executive Summary

# Executive Summary

1. Goa, one of the smallest states of India, has witnessed a growth in iron ore production since 1970s and especially in the last 5 years. The iron ore sector, which essentially comprises a high share in total mining and quarrying sector (share 93 to 94%) in Goa, shows a wide divergence of contribution of the mining and quarrying sector to the state GDP when measured in current prices.

2. The share of iron ore sector in state GDP is only 4.8 per cent in 2007-08 when measured at constant 1999-00 prices. However, measuring at constant prices would be an erroneous attempt. This is because measuring at constant prices does not factor in the structural changes in the international iron ore industry's and the following global supply shock that affected the domestic iron ore industry too.

3. Implications of this structural change would mean that any attempt to gauge the contribution of iron ore sector to the Goa state economy in constant 1999-00 prices would be a gross under-estimation. The contribution of iron ore sector is assessed to be 10.1 per cent in 2007-08 when measured at current prices.

4. The value of contribution from Mining and Quarrying to GSDP based on factor prices by the state government is underestimated by 33% and needs to be reviewed. This is because entries at factor cost is specific to mine head and excludes transport cost, transhipment cost, insurance costs, loading and unloading costs. When accounted at market prices, the value of output per national level norms should be around twice the output at factor cost.

5. This mining and quarrying industry generates a substantial output multiplier and income multiplier, thus generating a considerable demand in the Goan economy. The output multiplier for the mining and quarrying industry at 2007-08 is estimated to be 1.45, which means that for every unit of output produced in the mining sector, the total output generated in the economy is 1.45. This includes both direct and indirect output generation from all the sectors. The income multiplier for Mining and Quarrying industry is estimated to be 0.98. This means that for every unit of output produced in the industry, the direct and indirect value-added generated is 0.98 units in the economy.

6. The total share of iron ore industry at current prices is 10.14% in Goa's GSDP, which will go up if the indirect contribution due to the multiplier effect is accounted for. If the underestimation of GSDP by Mining and Quarrying is further corrected as mentioned in point 4, the share will go up further to approximately 16.94%.

7. The employment multiplier measures the direct and indirect employment generated in man years per lakh of output generated. For the mining industry, employment multiplier was 0.41 man-years per lakh of output at 2007-08 prices.

8. Its contribution to export, employment and forex reserve for the state makes it an important industry to be evaluated for its sustained contribution in the future.

9. A social cost benefit analysis is carried out for the Iron ore industry in Goa. The social benefits due to operation of this industry include

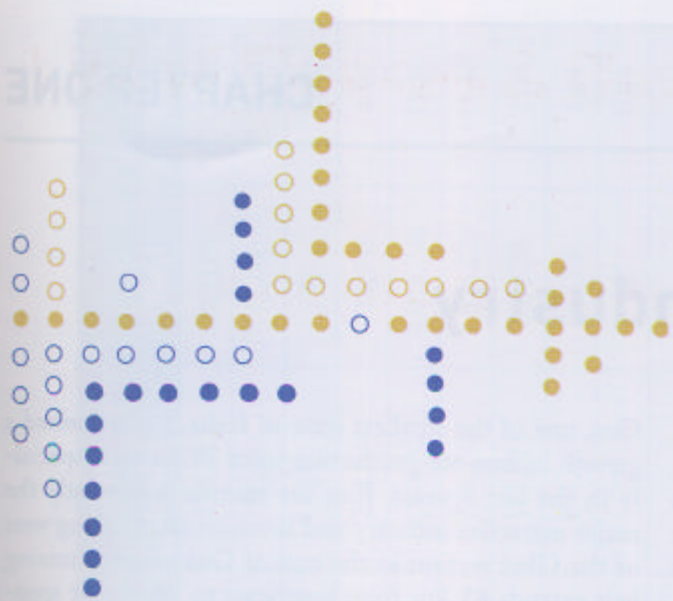
   - carbon credit benefits,
   - subsidy saved on diesel,
   - premium in terms of foreign exchange earned due to exports,
   - taxes paid to Central and State government in terms of royalty, barge tax, road infrastructure, corporate income differentials and export duties

   The social costs specific to this industry include

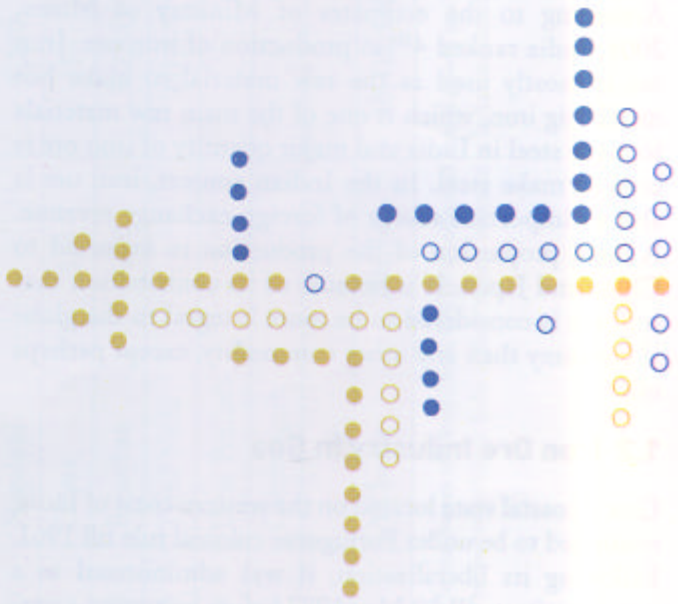
   - Loss of income due to environmental degradation that includes air pollution, unaccounted cost of landfill sites, deforestation.

10. The costs associated with giving up the iron ore industry in Goa (Opportunity Cost) would be greater by Rs 1,842.20 Crore per year than costs to the environment associated with running the industry.
11. The Net Present Value of the opportunity cost (for 25 years at 12% social discount rate) of giving up the iron ore industry is greater than the environmental cost of the iron ore industry by Rs 14,449 Crores.
12. Given the fragility of the Goan ecosystem, the Government has prepared a broad based regional plan to implement certain policy measures to maintain the balance of the same. The mining industry has responded to this by taking up a number of measures for the sustainable growth of the industry with respect to

- Environment Protective Measures
- Air Pollution Control Measures
- Top Soil Conservation
- Plantation
- Mineral Conservation and other environmental measures



# Goa and Iron-Ore Industry



CHAPTER ONE

# Goa and Iron-Ore Industry

## 1.1 Introduction

The tradition of mining in the India is ancient and has undergone considerable modernization along with the rest of the world after India's independence in 1947. The country produces and works with roughly 100 minerals, which are an important source for earning foreign exchange as well as satisfying domestic needs. Among the various minerals that are mined, India has significant sources of iron ore in its North Eastern Peninsular belt and South Western belt.

Iron ores are rocks and minerals from which metallic iron can be economically extracted. In India, the iron ore is usually found in the form of magnetite ($Fe_3O_4$) and hematite ($Fe_2O_3$). They are also categorized based on their physical characteristics like shape and size (such as lumps, fines or concentrates). The variations of iron ore observed in terms of Fe (iron) content are also important from the point of view of their end-use. Iron ores with Fe content more than 65% are categorised as high grades while those with Fe content less than 62% are categorized as low grades.

According to the estimates of Ministry of Mines, 2008, India ranked 4$^{th}$ in production of iron ore. Iron ore is mostly used as the raw material to make hot metal/ pig iron, which is one of the main raw materials to make steel in India and major quantity of iron ore is used to make steel. In the Indian context, iron ore is also an important source of foreign exchange revenue. A large proportion of the production in exported to China and Japan. It is because of its contribution that iron ore is considered to be more integral to the global economy than any other commodity, except perhaps oil.

## 1.2 Iron Ore Industry in Goa

Goa, a coastal state located on the western coast of India, continued to be under Portuguese colonial rule till 1961. Following its liberalization, it was administered as a union territory till 30 May 1987 before becoming a separate state.

Goa, one of the smallest state of India, has witnessed a growth in iron ore production since 1970s and especially in the last 5 years. Iron ore mining is currently the major extractive industry and is concentrated along west of the Ghat section in the east of Goa where a mining belt extends 65 km from southeast to northwest spanning some 700 sq. km (Central Pollution Control Board (CPCB), (2007)). Goa is the only state in India where such a iron ore mines are concentrated in such a small lease areas of less than 100 hacs.

The Goan iron ore industry is wholly dependant on exports. All the iron ore produced in Goa is exported to Japan, China, Korea, Taiwan and some European countries. This is because the total iron ores production from the state is less suitable for steel production (lower the iron content, higher the quantum of fines) in the country at the given level of technology and domestic demand. In India, Hematite is found more in abundance than Magnetite as evident from Table 1.1. However, it is the high grade Hematite rather than Magnetite type of iron ore that is primarily used for the production of steel in India. Goa accounts for mere 2.02% of total Magnetite iron ore (resources and reserves) and 4.87% of total Hematite ores (resources and reserves) in India as of 2005.

Besides, Goa's iron ore is comparatively of low grades (Fe content ranges in between 50% to 62%). This is evident from Table 1.2 which shows that among the fines and lumps produced in India, Goa's accounts for the maximum share in production of ore with less than 60%. Besides, Goa ore being more friable generates a higher quantum of fines. An elaborate process of beneficiation/concentration is required to make it fit to use by the steel industry. Goan ore does not have enough Fe content to justify a steel plant based on it. Finally, there is huge demand for Goan Ore globally as it is often used as a product blend to make up for the optimal Silica, Alumina content with ore from other parts of the world.

Moreover, Goa uses the logistic advantage of inland transportation to move iron ore to ports for exports. The cost of transporting ores to ports by inland waterways

**Table 1.1: Iron Ore Reserves and Resource Position in India in 2005 (thousand tons)**

| Sl. No. | State | Magnetite | | | | Haematite | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Reserves | Resources | Total | Share % | Reserves | Resources | Total | Share % |
| 1 | Andhra Pradesh | - | 1,463,541 | 1,463,541 | 13.78 | 39,596 | 123,443 | 163,039 | 1.11 |
| 2 | Assam | - | 15,380 | 15,380 | 0.14 | - | 12,600 | 12,600 | 0.09 |
| 3 | Bihar | - | 2,659 | 2,659 | 0.03 | - | 55 | 55 | 0.00 |
| **4** | **Goa** | **50,112** | **164,057** | **214,169** | **2.02** | **458,704** | **254,244** | **712,948** | **4.87** |
| 5 | Jharkhand | 3,391 | 6,879 | 10,270 | 0.10 | 2,494,423 | 1,541,323 | 4,035,746 | 27.58 |
| 6 | Karnataka | 148,437 | 7,663,347 | 7,811,784 | 73.56 | 940,430 | 735,792 | 1,676,222 | 11.46 |
| 7 | Madhya Pradesh | - | 83,435 | 83,435 | 0.79 | 33,917 | 171,021 | 204,938 | 1.40 |
| 8 | Maharashtra | 621 | - | 621 | 0.01 | 13,997 | 251,359 | 265,356 | 1.81 |
| 9 | Meghalaya | - | 3,380 | 3,380 | 0.03 | - | 225 | 225 | 0.00 |
| 10 | Nagaland | - | 5,280 | 5,280 | 0.05 | - | - | - | - |
| 11 | Orissa | 156 | 54 | 210 | 0.00 | 2,251,777 | 2,508,848 | 4,760,625 | 32.54 |
| 12 | Rajasthan | 4,225 | 522,652 | 526,877 | 4.96 | 10,813 | 19,035 | 29,848 | 0.20 |
| 13 | Tamil Nadu | - | 481,876 | 481,876 | 4.54 | - | - | - | - |
| 14 | Uttar Pradesh | - | - | - | - | - | 38,000 | 38,000 | 0.26 |
| 15 | Chhattisgarh | - | - | - | - | 760,512 | 1,970,275 | 2,730,787 | 18.67 |
| | | | | | | | | | |
| | **All India** | **206,941** | **10,412,540** | **10,619,481** | **100.00** | **7,004,169** | **7,626,220** | **14,630,389** | **100.00** |

Source: Indian Bureau of Mines (Note: CAGR is compound annual growth rate).

Note: The reserve portion in India is likely to have increased in India substantially for all states as the threshold values for Iron ores have been reduced to 45% Fe.

**Table 1.2: Production of Different Grades of Iron-ore in India and Goa in ('000 ton, '000 Rs.)**

| | | 2000-2001 | | | 2004-2005 | | | 2006-2007 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | India | Goa | Goa's %age in India | India | Goa | Goa's %age in India | India | Goa | Goa's %age in India |
| **Lumps** | No of mines | 208 | 46 | **22.12** | 281 | 65 | **23.13** | 290 | 67 | **23.10** |
| | Below 60% | 1,871 | 1,739 | **92.94** | 3,834 | 2,929 | **76.40** | 9,085 | 4,227 | **46.53** |
| | 60%-62% | 4,070 | 1,145 | **28.13** | 4,448 | 949 | **21.34** | 6,447 | 1,762 | **27.33** |
| | 62%-65% | 11,309 | 390 | **3.45** | 19,975 | 365 | **1.83** | 32,898 | 617 | **1.88** |
| | 65% & above | 16,317 | 6 | **0.04** | 30,095 | - | **0.00** | 39,880 | - | **0.00** |
| | Total | 33,567 | 3,280 | **9.77** | 58,152 | 4,243 | **7.30** | 88,310 | 6,656 | **7.54** |
| | Value (Rs) | 8,110,788 | 874,167 | **10.78** | 32,999,793 | 1,783,714 | **5.41** | 75,495,106 | 3,910,153 | **5.18** |
| **Fines** | Below 62% | 7,083 | 5,064 | **71.50** | 19,392 | 11,594 | **59.79** | 27,368 | 14,713 | **53.76** |
| | 62%-65% | 19,262 | 5,168 | **26.83** | 37,375 | 5,891 | **15.76** | 50,871 | 6,197 | **12.18** |
| | 65% & above | 14,844 | 46 | **0.31** | 25,770 | 41 | **0.16** | 20,001 | 11 | **0.05** |
| | Total | 41,189 | 10,278 | **24.95** | 82,537 | 17,526 | **21.23** | 98,240 | 20,921 | **21.30** |
| | Value (Rs.) | 9,049,475 | 2,991,569 | **33.06** | 35,136,558 | 7,169,046 | **20.40** | 65,930,057 | 14,910,891 | **22.62** |
| **Concentrates** | Total | 6,006 | 1,006 | **16.75** | 5,253 | 903 | **17.19** | 1,146 | 1,146 | **100.00** |
| | Value | 4,107,119 | 143,219 | **3.49** | 5,892,678 | 333,378 | **5.66** | 617,921 | 617,921 | **100.00** |
| **Total** | Total | 80,762 | 14,564 | **18.03** | 145,942 | 22,672 | **15.53** | 187,696 | 28,723 | **15.30** |
| | Value (Rs.) | 21,267,382 | 4,008,955 | **18.85** | 74,029,029 | 9,286,138 | **12.54** | 142,043,084 | 19,438,965 | **13.69** |

Source: Indian Bureau of Mines, Govt. of India.

works out to be a more efficient mode of transportation by wagons and, thus, provides cost competitiveness to exports of even low Fe content lumps and fines.

## 1.3 Purpose of this Study

This study is a comprehensive and analytical review of the iron ore mining industry of Goa that studies the economic and social impact on the state as well as the national economy. The primary focus of the study is to assess the contribution of the iron ore industry to the economic development of the Goan economy. The fundamental objectives of the study are as follows:

- Importance of the iron ore mining industry to the Goan economy. It will cover both direct and indirect contributions of the sector. The direct one is taken to indicate, inter alia, the contribution of the constituent iron ore-mining firms to the economy in the form of output, employment, taxes, and foreign exchange etc. The indirect impact, on the other hand, records the gains made by the other sectors of the economy that have linkages with the iron ore mining.
- Social and economic benefits accrued to the Goan economy, both to the local and wider societies, from the iron ore mining industry.
- To evaluate changes in Governmental policies specific to the mining industry, and the corporate initiatives in response to these policy changes.

## 1.4 The Relevance of the Study

This study is important in the context of Goa because the iron ore sector, which essentially comprise a high share in total mining and quarrying sector (share 93 to 94%), show the wide divergence of contribution of the mining and quarrying sector to the state GDP when measured in current and constant 1999-00 prices. Table 1.3 illustrates the point.

The divergence in shares at current prices and constant prices have become significant since the year 2006-07 and peaked in the years 2007-08 and 2008-09 (extrapolations). To indicate the share of iron ore sector in state GDP as only 4.8 per cent in constant 1999-00 prices would be an erroneous attempt that does not factor in the structural changes in the international iron ore industry and the following global supply shock that affected the domestic iron ore industry too. The contribution of iron ore sector must be assessed at 10.1 per cent to reflect the current reality. **Thus, iron ore industry contribution to the Goan GDP is considerably underestimated when it is measured at 1999-00 prices.**

Besides, this industry also generates a substantial output multiplier and value added multiplier (which will be detailed in the subsequent chapters), thus generating a considerable demand in the Goan economy. Its contribution to export, employment and forex reserve for the state makes it an important

**Table 1.3: Share of Mining in GSDP of Goa at Current and Constant (1999-00) Prices**

| Year | Share of Mining and Quarrying in State GSDP at Current Prices (per cent) | Share of Mining and Quarrying in State GSDP at Constant 1999-00 Prices (per cent) |
|---|---|---|
| 1999-00 | 4.2 | 4.2 |
| 2000-01 | 3.6 | 3.5 |
| 2001-02 | 3.9 | 4.1 |
| 2002-03 | 4.1 | 4.3 |
| 2003-04 | 4.7 | 4.5 |
| 2004-05 | 5.3 | 4.6 |
| 2005-06 | 5.0 | 4.0 |
| 2006-07 | 9.2 | 5.2 |
| 2007-08 | 10.1 | 4.8 |

Source: Directorate of Economics & Statistics of respective State Governments, and for All-India - Central Statistical Organisation, mospi.nic.in

**Box 1.1: Challenges Faced by the Mining Industry**

- Mining activity in several places is being carried out below the water table, which required dewatering of pits for operation to continue.
- Restricted drilling and blasting due to limited lateritic overburden, presence of villages and inhabited areas in the vicinity of the mines.
- Restricted lateral mine development due to smaller areal extension since the lease area of individual mines is less than 100 ha.
- Transport is a problem within the mine, due to greater working depth.
- Congestion in road network due to limited width of roads, sometimes passing through populated areas.
- High overburden to ore ratio (of an average of about 2.5 to 3.0:1) implies that a large amount of overburden is generated when ore is extracted. Since the mining leases are less than 100 ha, there is very limited space (or non at all) available within the lease area to dump the waste material. This leads to requiring land outside the lease area for dumping rejects.
- Land being in short supply, dumps are typically steep with slopes greater than 30° and height of 30-50 Mts. Many waste dumps are situated in the upper part of the valley regions and during monsoon, run off from dumps is common, which blankets agricultural fields and settles in water courses.
- Because of small holdings, large amount of ore is blocked in barriers of adjoining mines; operations could be carried out close to common boundaries of two lease holders with mutual understanding. Structurally, majority of ore deposits are in synclinal form. Consequently, almost 60% (by volume) of ore production comes from terrain below ground water table.

industry to be evaluated for its sustained contribution in the future.

However, in the recent years, the operation of Iron ore industry in Goa has been under strict vigilance as there have been arguments about restricting this industry from further operation. The arguments against continuing operation of this industry come primarily from the environmental perspectives. Box 1.1 specifies some of the difficult conditions specific to Goan iron ore mines.

Centre for Science and Environment (CSE) based out of Delhi published a report in 2006 titled 6th State of India's Environment report. The report disputed the contention that mining is essential for growth of the economy and generation of employment. The CSE report points out that mining cannot be sustainable or truly environment-friendly. This is because wastes from this industry are non-renewable and have significant environmental implications. In its chapter on Goa, the report argues that Goa mining industry don't conform to the existing environmental regulations of India. The report claims that the mining operations are carried out in the backyards of people's homes, farms and forests. Strong miners' influence and poor law enforcement results in pollution of air and water. This in turn have severe implications on homes and health of people, forests and water bodies of the state. The report also argues that increasing exports along with increase in demand from China are sending prices and profits sky high. According the report, Goa is also the only state where the High Court has directed the companies to compensate against the losses incurred by farmers because mine rejects have silted their fields and damaged their water courses.

This study tries to address the economic and social impact of iron ore industry of Goa in light of the above arguments. A quantitative analysis of the contribution of the iron ore industry together with assessment of the environmental effects based on available studies will provide a better understanding of Iron Ore industry and its operations to the Goan economy.

## 1.5 Methodology Used for Quantitative and Qualitative Analysis

Input- output techniques deal with the quantitative analysis of the interdependence among various producing sector of the economy as well as the different components of the final demand. Thus, if the interest is in producing one unit of a particular product, its impact

on the production of the other factors of production (output multiplier) can be through Input-Output analysis. Also the employment multiplier can be gauged using Direct Labour Coefficients. These multipliers enable us to position the sector vis-à-vis other sectors of the natural economy.

Social Cost benefit analysis has been carried out to analyse the social benefits obtained from iron ore industry and to evaluate the pollution abatement costs associated with this industry. Under the SCB method, project cost benefits are restated as the opportunity cost. The social discount rate used in the yield of marginal public sector included in the plan document and/or the opportunity cost of capital. The value is restated in terms of the uncommitted social income in the hands of government.

## 1.6 Structure of the Report

For a better understanding of Iron Ore industry and its operations, we have provided a brief review of overview of Iron ore industry in Goa. In Chapter 3, we have outlined the Input-Output table and have estimated the output and value added multiplier. Chapter 4 gives a brief account of the social benefits and social costs associated with the operation of mining iron ore industry in Goa. A Social Cost Benefit matrix has been estimated for this industry in Chapter 5 in order to evaluate its impact on the society, environment and on the economy. Governmental policies specific to the mining industry and the corporate initiatives in response to these policy changes have been examined in Chapter 6. And, finally, Chapter 7 summarises the findings along with our argument for continuation of Mining Iron ore industry in Goa.

# Iron Ore Industry's Contribution to Goan Economy

CHAPTER TWO

# Iron Ore Industry's Contribution to Goan Economy

The iron ore industry to the Goan economy has been the second most important industry next to Tourism industry. Its contribution to Goan GDP, export and employment has been substantial. The contribution of this industry in terms of GDP has been controversial based on its measurement at current and constant prices specifically for the years after 2000. The contribution of this industry has been detailed in the following sections.

## 2.1 Contribution to Goa's Gross State Domestic Product (GSDP): The Debate of Measuring at Current Vs Constant Prices

The structure of Goa's economy indicates its peculiarity. Firstly, Goa's economy has undergone a considerable structural change after its formation in 1987, more specifically after 1999-00. The contribution of the 'Agricultural and allied sector' to Goa's GSDP at current prices declined from 12.3% in 1999-00 to 7.3% in 2007-08. The major contribution at current prices came from the services sector in 1999-00 that contributed 49.1 percent in 1999-00. The contribution however consistently dropped over the subsequent years to 44.2 percent in 2003-04 and finally to 40.5 percent in 2007-08. Within the services sector, 'trade, hotels and restaurants' recorded diminishing contributions to GSDP from 1999-00 onwards. The share of Trade, hotels and restaurants at current prices came down from 15.2 percent in 1999-2000 to 10.4 percent 2007-08.

The industry sector recorded a constant growth in the share of GSDP at current prices, from 38.6 percent in 1999-00 to 52 percent in 2007-08. Within industry, manufacturing sector, both registered and unregistered, recorded a marginal growth from 27 percent in 1999-00 to 30 percent in 2007-08.

In broad terms, when GSDP was measured at current prices, while the secondary sector continued to grow, the contribution of the tertiary sector were found to be moving in the opposite direction. The primary sector however had lost its importance by 2007-08. Thus, all the three sectors recorded three different growth experiences after 1999-2000, when measured at current prices.

One of the surprising observations was the increase in the share of the 'mining and quarrying' sector that recorded a significant increase after 2003-04. Its contribution of 4.1 percent in 1999-00 grew marginally to 4.7 percent in 2003-04. However, by 2007-08 its share jumped up to 10.1 percent (see Table 2.1). This increase in share was captured only when GSDP was measured at current prices. However, when measured at constant 1999-00 prices, the contribution of this sector increased marginally. Its share to GSDP at 1999-00 prices increased from 4.2 percent in 1999-00 to 4.5 percent in 2003-04 and further to 4.8% in 2007-08 (see Table 2.2). This is sharply in contrast to the shares calculated based on current prices. This deviation is reflective of the sudden increase of iron ore prices in the international markets during Dec-March 2007-08 which, when measured at constant prices do not get reflected.

In the following section we explain the reason for this jump in shares of the mining and quarrying industry of Goa, when being measured at current prices.

### 2.1.1 Global Developments, Commodity Prices and Supply Shock – Iron Ore

A sudden spurt of international commodity prices in the last quarter of the calendar year 2007 was accompanied with an appreciation of the rupee during the last quarter of 2007-08. The global supply shock was witnessed in the iron ore international market during January 2008 when prices shot up significantly by over 65% from 85 cents/d mtu to 140 cents/dmts as shown in Figure 2.1. Given the global origin of the supply shock in Iron Ore,

**Table 2.1: Present Share Agriculture, Industry and Services in GSDP at Current Prices (Rs. Lakh)**

| GSDP at Factor Cost By Industry Of origin at Current Prices Base Year 1999-2000 (Rs Lakh) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sectors | 1999-00 | Share % | 2003-04 | Share % | CAGR | 2007- 08 | Share % | (CAGR) Compounded Annual Growth Rate |
| **Agriculture & Allied** | **77,730** | **12.28** | **88,039** | **9.47** | **3.16** | **124,658** | **7.24** | **9.08** |
| Agriculture | 63,726 | 10.07 | 61,849 | 6.65 | -0.74 | 80,343 | 4.67 | 6.76 |
| Forestry & Logging | 909 | 0.14 | 1,126 | 0.12 | 5.50 | 2,049 | 0.12 | 16.15 |
| Fishing | 13,095 | 2.07 | 25,064 | 2.69 | 17.62 | 42,266 | 2.46 | 13.96 |
| **Industry** | **244,362** | **38.61** | **431,134** | **46.35** | **15.25** | **899,158** | **52.23** | **20.17** |
| Mining & Quarrying | 26,355 | 4.16 | 43,978 | 4.73 | 13.66 | 174,633 | 10.14 | 41.16 |
| Manufacturing | 172,442 | 27.24 | 297,312 | 31.96 | 14.59 | 561,677 | 32.63 | 17.24 |
| Manu-Registered | 144,621 | 22.85 | 257,190 | 27.65 | 15.48 | 485,524 | 28.20 | 17.22 |
| Manu-Unregistered | 27,821 | 4.40 | 40,122 | 4.31 | 9.59 | 76,153 | 4.42 | 17.38 |
| Construction | 35,108 | 5.55 | 62,731 | 6.74 | 15.62 | 132,773 | 7.71 | 20.62 |
| Electricity, gas and water supply | 10,457 | 1.65 | 27,113 | 2.91 | 26.89 | 30,075 | 1.75 | 2.63 |
| **Services** | **310,883** | **49.11** | **410,962** | **44.18** | **7.23** | **697,643** | **40.53** | **14.15** |
| Transport, storage & communication | 60,993 | 9.64 | 107,102 | 11.51 | 15.11 | 181,696 | 10.55 | 14.13 |
| Railways | 2,061 | 0.33 | 3,211 | 0.35 | 11.72 | 9,497 | 0.55 | 31.14 |
| Transport by other means | 55,705 | 8.80 | 98,698 | 10.61 | 15.37 | 146,609 | 8.52 | 10.40 |
| Storage | 285 | 0.05 | 402 | 0.04 | 8.98 | 631 | 0.04 | 11.93 |
| Communication | 2,942 | 0.46 | 4,791 | 0.52 | 12.97 | 24,959 | 1.45 | 51.08 |
| Trade, hotels & restaurants | 96,300 | 15.21 | 87,930 | 9.45 | -2.25 | 179,188 | 10.41 | 19.48 |
| Banking & insurance | 53,670 | 8.48 | 78,727 | 8.46 | 10.05 | 128,261 | 7.45 | 12.98 |
| Real estate, ownership of dwellings and business services | 37,564 | 5.93 | 59,631 | 6.41 | 12.25 | 95,292 | 5.54 | 12.43 |
| Public administration | 34,184 | 5.40 | 43,652 | 4.69 | 6.30 | 62,785 | 3.65 | 9.51 |
| Other services | 28,172 | 4.45 | 33,920 | 3.65 | 4.75 | 50,421 | 2.93 | 10.42 |
| **State domestic product (Rs. Lacs)** | **632,975** | **100.00** | **930,135** | **100.00** | **10.10** | **1,721,459** | **100.00** | **16.64** |

Source: mospi.nic.in.

a judgment had to be made on the exact proportion of temporary and permanent elements of such changes in the global prices.

One had to analyze whether or not the iron ore prices overshot the long-term supply price of ore. A preliminary analysis of the movement of global iron ore prices confirms the global supply shock in the iron ore market (Economic Survey 2008-09). We assume that the prices for iron ore with Fe content 63 per cent or less (which is majorly produced and exported from Goa) has also seen a similar increase in prices. This is shown in Figure 2.1.

## Table 2.2: Present Share Agriculture, Industry and Services in GSDP at Constant Prices (Rs. Lakh)

| GSDP at Factor Cost by Industry of Origin at 1999-2000 Prices (Rs. Lakh) | | | | | | |
|---|---|---|---|---|---|---|
| Sector | 1999-00 | Share % | 2003-04 | Share % | 2007-08 | Share % |
| **Agriculture and Allied** | **77,730** | **12.28%** | **78,187** | **10.67%** | **69,835** | **6.33%** |
| Agriculture | 63,726 | 10.07% | 55,386 | 7.56% | 46,379 | 4.21% |
| Forestry & logging | 909 | 0.14% | 1,151 | 0.16% | 1,146 | 0.10% |
| Fishing | 13,095 | 2.07% | 21,650 | 2.95% | 22,310 | 2.02% |
| **Industry** | **244,362** | **38.61%** | **314,379** | **42.89%** | **455,502** | **41.31%** |
| Mining & quarrying | 26,355 | 4.16% | 32,804 | 4.48% | 52,953 | 4.80% |
| Manufacturing | 172,442 | 27.24% | 226,170 | 30.86% | 331,759 | 30.08% |
| Manu-Registered | 144,621 | 22.85% | 191,410 | 26.12% | 279,896 | 25.38% |
| Manu-Unregistered | 27,821 | 4.40% | 34,760 | 4.74% | 51,863 | 4.70% |
| Construction | 35,108 | 5.55% | 39,244 | 5.35% | 52,004 | 4.72% |
| Electricity, gas and Water supply | 10,457 | 1.65% | 16,161 | 2.20% | 18,786 | 1.70% |
| **Services** | **310,883** | **49.11%** | **340,372** | **46.44%** | **57,7426** | **52.36%** |
| Transport, storage & communication | 60,993 | 9.64% | 99,770 | 13.61% | 25,7442 | 23.35% |
| Railways | 2,061 | 0.33% | 2,953 | 0.40% | 8,018 | 0.73% |
| Transport by other means | 55,705 | 8.80% | 90,001 | 12.28% | 178,711 | 16.21% |
| Storage | 285 | 0.05% | 357 | 0.05% | 463 | 0.04% |
| Communication | 2,942 | 0.46% | 6,459 | 0.88% | 70,250 | 6.37% |
| Trade, hotels and restaurants | 96,300 | 15.21% | 73,257 | 9.99% | 77,771 | 7.05% |
| Banking & Insurance | 53,670 | 8.48% | 62,343 | 8.51% | 117,902 | 10.69% |
| Real estate, ownership of dwellings and business services | 37,564 | 5.93% | 46,493 | 6.34% | 60,766 | 5.51% |
| Public administration | 34,184 | 5.40% | 29,414 | 4.01% | 30,253 | 2.74% |
| Other services | 28,172 | 4.45% | 29,095 | 3.97% | 33,292 | 3.02% |
| **State domestic product (Rs. lacs)** | **632,975** | **100.00%** | **732,938** | **100.00%** | **1,102,763** | **100.00%** |

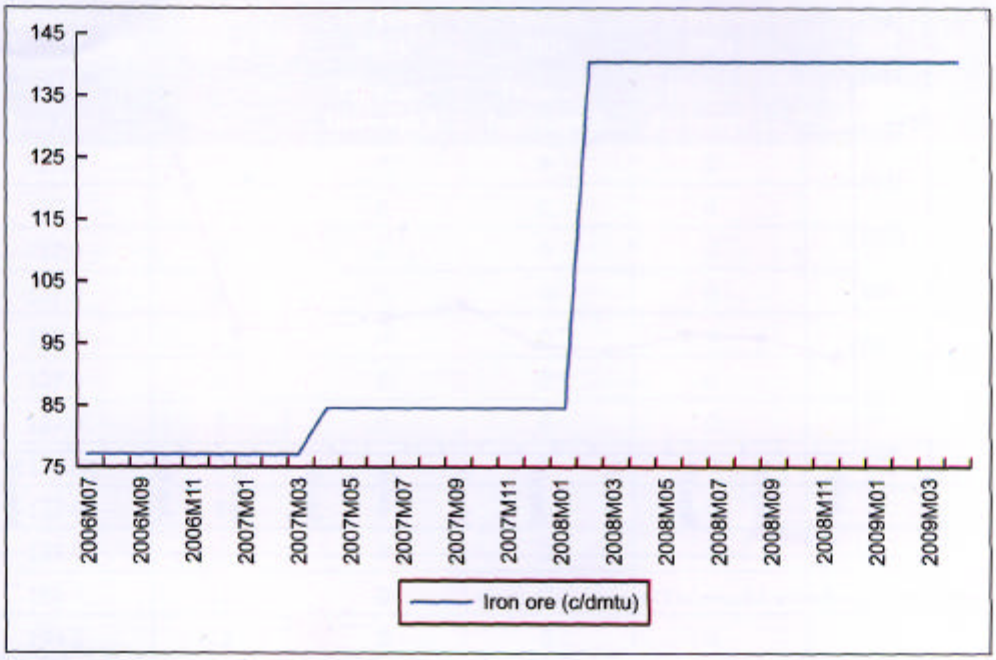
Source: mospi.nic.in.

While crude oil prices, prices of petroleum products, edible oil prices all rose abruptly in January 2008, most of these abrupt increases in prices were found to be of temporary nature and the prices soon realigned with the long run supply prices of these commodities. However, this was not the case for Iron Ore. The global supply shocks that were observed in January 2008, were of permanent nature and that the 'new normal' long run supply prices of iron ore had significantly changed. One had to factor in such permanent changes of international ore prices in the domestic economy context.

### Global Supply Shock: Iron Ore and the WPI Inflation

During the five year period of high growth from 2003-04 to 2007-08 WPI inflation had gone through two cycles. The first peak in August 2004 was followed by a trough in August 2005 and the second peak in March 2007 was followed by a trough in October 2007. There was a subsequent upturn in 2007 prices following an increase in capital flows.

**Figure 2.1: Times Series of International Prices of Iron Ore**




Source: Economic Survey 2008-09.

The crucial question before us is whether the WPI iron ore prices reflected the general WPI price movements or did it reflect structural changes in March 2007 and subsequently in January 2008. Price movements of commodities in the domestic economy are measured by WPI indices (Base 1993-94=100). Figure 2.2 shows the movement of WPI for iron ore during July 2006-May 2008.

Figure 2.3 show the movement of WPI of iron ore in relation to all other commodities and metallic minerals. The fact that the WPI price movements of iron ore are akin to international price movements of iron ore and quite different from the WPI price movements of all commodities is shown in the Figure 2.3.

Implications of this structural change would mean that any attempt to gauge the contribution of iron ore sector to the Goa state economy in constant 1999-00 prices would be a gross under-estimation, for they do not take into account the structural changes that took place during the year 2007-08. The share of iron ore sector in the state economy measured at current prices would be a fair estimate of its contribution.

## The Evidence of the Structural Change

With prior knowledge of specific events and approximate dates in the international market for iron ore, it is not difficult to examine their relevance for regression models. We need additional regressors such as the dummy variables that accommodate for the various possible patterns.

A very useful model to characterize set of WPI data (iron ore) in economic time series is to allow for the presence of a changing deterministic trend. It may occur that a certain event such as the global supply shock in Iron ore international market changes the structure of Goa Iron Ore business and Goa's economic structure such that trends before the event has diverged towards a different trend. A simple regression model that allows for a changing trend is given by

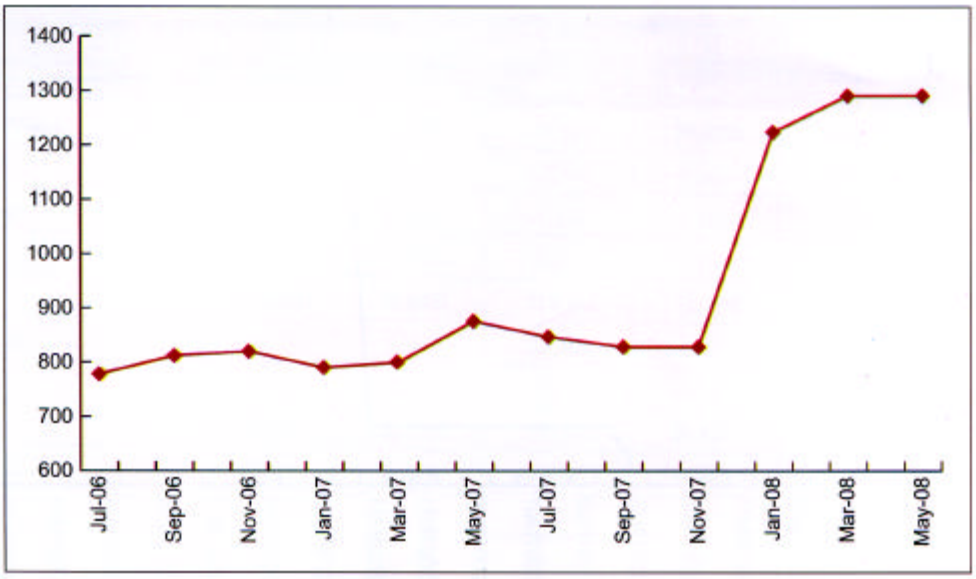
$$Y(t) = Vt + wI(t)\ (t>=r) + \text{error terms}$$

where the trend is V until time r and v+w from r onwards.

Alternatively, there may not be a change in trend after the global supply shock but a mere "intercept" change. Maybe there could have been changes in both the intercept values as well as trend values. Standard tests for significance can be used to decide which regressors are potentially important in the model.

This approach was adopted for analyzing the monthly data on WPI Iron Ore prices in the domestic economy.

**Figure 2.2: Domestic WPI Index Movement for Iron Ore**

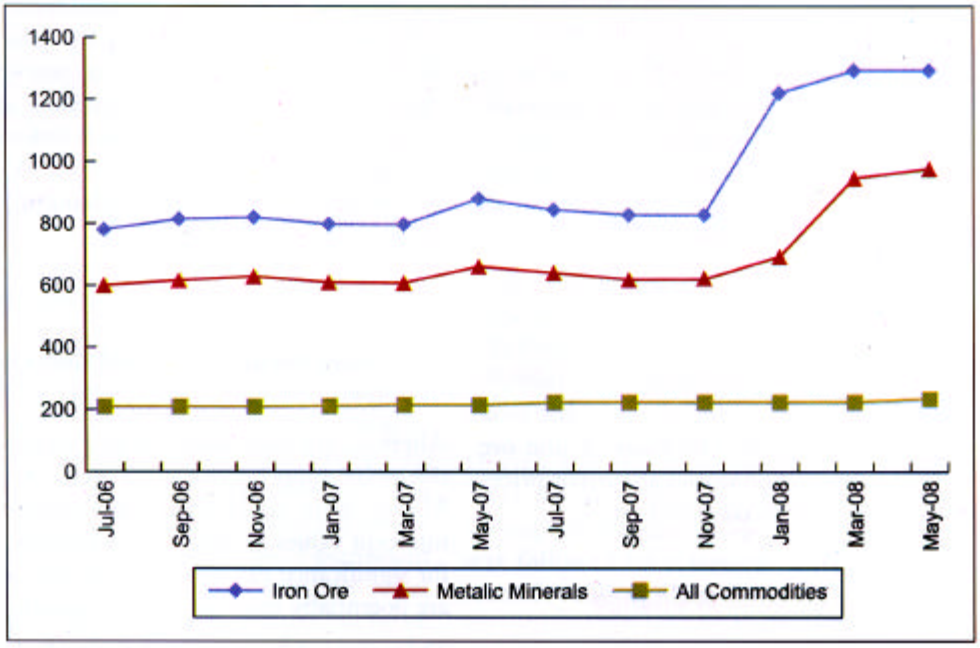



Source: Office of the Economic Advisor-Ministry of Commerce and Industry

XLSTAT was used to estimate the parameters of the regression model and to test the significance of these parameters. These are succinctly mentioned in Table 2.3.

The WPI time series data pertaining to iron ore used in the regression is shown below. Dummy trend variables were assumed for February 2008 following the global supply shock in Iron-ore market witnessed in January 2008. The WPI time series data suggest that there could have been a trend change in August 2005 prior to the global supply shock. Intercept dummies were

**Figure 2.3: Domestic WPI Movement for All Commodities, Metalic Minerals and Iron Ore**




Source: Office of the Economic Advisors Ministry of Commerce and Industry.

**Table 2.3: The Variables Considered for Regression**

| | Independent Variable | Time Trend | Dummy for June 2004 | Dummy : August 2005 | Dummy: February 2004 | Slope: August 2005 | Slope: February 2008 |
|---|---|---|---|---|---|---|---|
| Year | Iron Ore | X | Dummy Intercept 1 | Dummy Intercept 2 | Dummy Intercept 3 | Dummy slope 4 | Dummy slope 5 |
| Apr, 03 | 127.0 | 1 | 0 | 0 | 0 | 0 | 0 |
| May, 03 | 127.0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Jun, 03 | 127.0 | 3 | 0 | 0 | 0 | 0 | 0 |
| Jul, 03 | 127.0 | 4 | 0 | 0 | 0 | 0 | 0 |
| Aug, 03 | 127.0 | 5 | 0 | 0 | 0 | 0 | 0 |
| Sep, 03 | 127.0 | 6 | 0 | 0 | 0 | 0 | 0 |
| Oct, 03 | 127.0 | 7 | 0 | 0 | 0 | 0 | 0 |
| Nov, 03 | 127.0 | 8 | 0 | 0 | 0 | 0 | 0 |
| Dec, 03 | 127.0 | 9 | 0 | 0 | 0 | 0 | 0 |
| Jan, 04 | 127.0 | 10 | 0 | 0 | 0 | 0 | 0 |
| Feb, 04 | 160.7 | 11 | 0 | 0 | 0 | 0 | 0 |
| Mar, 04 | 194.3 | 12 | 0 | 0 | 0 | 0 | 0 |
| Apr, 04 | 194.3 | 13 | 0 | 0 | 0 | 0 | 0 |
| May, 04 | 267.7 | 14 | 0 | 0 | 0 | 0 | 0 |
| Jun, 04 | 534.9 | 15 | 1 | 0 | 0 | 0 | 0 |
| Jul, 04 | 500.6 | 16 | 1 | 0 | 0 | 0 | 0 |
| Aug, 04 | 512.3 | 17 | 1 | 0 | 0 | 0 | 0 |
| Sep, 04 | 529.7 | 18 | 1 | 0 | 0 | 0 | 0 |
| Oct, 04 | 499.2 | 19 | 1 | 0 | 0 | 0 | 0 |
| Nov, 04 | 508.6 | 20 | 1 | 0 | 0 | 0 | 0 |
| Dec, 04 | 496.7 | 21 | 1 | 0 | 0 | 0 | 0 |
| Jan, 05 | 474.2 | 22 | 1 | 0 | 0 | 0 | 0 |
| Feb, 05 | 439.1 | 23 | 1 | 0 | 0 | 0 | 0 |
| Mar, 05 | 421.9 | 24 | 1 | 0 | 0 | 0 | 0 |
| Apr, 05 | 425.8 | 25 | 1 | 0 | 0 | 0 | 0 |
| May, 05 | 447.0 | 26 | 1 | 0 | 0 | 0 | 0 |
| Jun, 05 | 498.8 | 27 | 1 | 0 | 0 | 0 | 0 |
| Jul, 05 | 494.5 | 28 | 1 | 0 | 0 | 0 | 0 |
| Aug, 05 | 591.4 | 29 | 1 | 1 | 0 | 29 | 0 |
| Sep, 05 | 673.1 | 30 | 1 | 1 | 0 | 30 | 0 |
| Oct, 05 | 679.8 | 31 | 1 | 1 | 0 | 31 | 0 |
| Nov, 05 | 680.1 | 32 | 1 | 1 | 0 | 32 | 0 |
| Dec, 05 | 709.8 | 33 | 1 | 1 | 0 | 33 | 0 |
| Jan, 06 | 698.6 | 34 | 1 | 1 | 0 | 34 | 0 |
| Feb, 06 | 663.3 | 35 | 1 | 1 | 0 | 35 | 0 |

| Year | Independent Variable<br>Iron Ore | Time Trend<br>X | Dummy for June 2004<br>Dummy Intercept 1 | Dummy : August 2005<br>Dummy Intercept 2 | Dummy: February 2004<br>Dummy Intercept 3 | Slope: August 2005<br>Dummy slope 4 | Slope: February 2008<br>Dummy slope 5 |
|---|---|---|---|---|---|---|---|
| Mar, 06 | 655.4 | 36 | 1 | 1 | 0 | 36 | 0 |
| Apr, 06 | 713.5 | 37 | 1 | 1 | 0 | 37 | 0 |
| May, 06 | 770.6 | 38 | 1 | 1 | 0 | 38 | 0 |
| Jun, 06 | 779.4 | 39 | 1 | 1 | 0 | 39 | 0 |
| Jul, 06 | 788.7 | 40 | 1 | 1 | 0 | 40 | 0 |
| Aug, 06 | 821.9 | 41 | 1 | 1 | 0 | 41 | 0 |
| Sep, 06 | 816.7 | 42 | 1 | 1 | 0 | 42 | 0 |
| Oct .06 | 828.5 | 43 | 1 | 1 | 0 | 43 | 0 |
| Nov, 06 | 827.0 | 44 | 1 | 1 | 0 | 44 | 0 |
| Dec, 06 | 798.3 | 45 | 1 | 1 | 0 | 45 | 0 |
| Jan, 07 | 791.8 | 46 | 1 | 1 | 0 | 46 | 0 |
| Feb, 07 | 793.7 | 47 | 1 | 1 | 0 | 47 | 0 |
| Mar, 07 | 796.3 | 48 | 1 | 1 | 0 | 48 | 0 |
| Apr, 07 | 816.3 | 49 | 1 | 1 | 0 | 49 | 0 |
| May, 07 | 873.2 | 50 | 1 | 1 | 0 | 50 | 0 |
| Jun, 07 | 864.3 | 51 | 1 | 1 | 0 | 51 | 0 |
| Jul, 07 | 847.5 | 52 | 1 | 1 | 0 | 52 | 0 |
| Aug, 07 | 825.7 | 53 | 1 | 1 | 0 | 53 | 0 |
| Sep, 07 | 827.8 | 54 | 1 | 1 | 0 | 54 | 0 |
| Oct, 07 | 827.8 | 55 | 1 | 1 | 0 | 55 | 0 |
| Nov, 07 | 827.8 | 56 | 1 | 1 | 0 | 56 | 0 |
| Dec, 07 | 839.8 | 57 | 1 | 1 | 0 | 57 | 0 |
| Jan, 08 | 932.5 | 58 | 1 | 1 | 0 | 58 | 0 |
| Feb, 08 | 1253 | 59 | 1 | 1 | 1 | 59 | 59 |
| Mar, 08 | 1,288.8 | 60 | 1 | 1 | 1 | 60 | 60 |
| Apr, 08 | 1,290.2 | 61 | 1 | 1 | 1 | 61 | 61 |
| May, 08 | 1,288.5 | 62 | 1 | 1 | 1 | 62 | 62 |
| Jun, 08 | 1,274.0 | 63 | 1 | 1 | 1 | 63 | 63 |
| Jul, 08 | 1,293.7 | 64 | 1 | 1 | 1 | 64 | 64 |
| Aug, 08 | 1,281.5 | 65 | 1 | 1 | 1 | 65 | 65 |
| Sep, 08 | 1,176.6 | 66 | 1 | 1 | 1 | 66 | 66 |
| Oct, 08 | 1,176.6 | 67 | 1 | 1 | 1 | 67 | 67 |
| Nov, 08 | 1,176.5 | 68 | 1 | 1 | 1 | 68 | 68 |
| Dec, 08 | 1,211.6 | 69 | 1 | 1 | 1 | 69 | 69 |
| Jan, 09 | 1,211.9 | 70 | 1 | 1 | 1 | 70 | 70 |
| Feb, 09 | 1,219.0 | 71 | 1 | 1 | 1 | 71 | 71 |
| Mar, 09 | 1,365.2 | 72 | 1 | 1 | 1 | 72 | 72 |

assumed for June 2004, August 2005 and February 2008 after a careful examination of the data.

The results of the estimate are given in Table 2.4. The final equation specified from the model is given by

Iron Ore WPI = 136.96+1.62*X+311.94*Dummy Intercept1+1,016.95*Dummy Intercept3+5.98*Dummy slope4-10.88*Dummy slope5

**Table 2.4: The Regression Estimates**

| Model Parameters | | | | | | |
|---|---|---|---|---|---|---|
| Source | Value | Standard error | T | Pr > \|t\| | Lower bound (95%) | Upper bound (95%) |
| Intercept | 136.956 | 15.448 | 8.866 | < 0.0001 | 106.113 | 167.799 |
| X | 1.615 | 1.389 | 1.163 | 0.249 | -1.159 | 4.389 |
| Dummy Intercept 1 | 311.944 | 23.368 | 13.349 | < 0.0001 | 265.289 | 358.599 |
| Dummy Intercept 3 | 1,016.951 | 188.017 | 5.409 | < 0.0001 | 641.563 | 1,392.339 |
| Dummy slope 4 | 5.975 | 0.834 | 7.163 | < 0.0001 | 4.310 | 7.641 |
| Dummy slope 5 | -10.879 | 2.910 | -3.739 | 0.000 | -16.688 | -5.069 |

Source: Estimated.

The major structural change had occurred in February 2008 as indicated by significant values of trend and intercept dummies in February 2008. Thus the model suggests that the role of the iron ore sector in the Goan economy would be quite significant if GDP iron ore share is assessed in constant post 2008 prices (or in current prices). The assessment of the iron ore sector role in constant 1999-00 prices would not be an appropriate and could be an understatement.

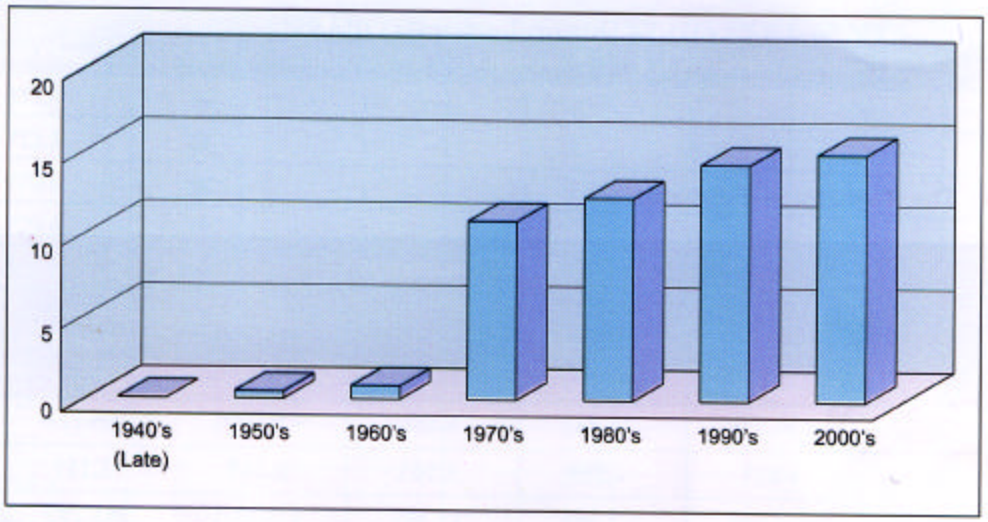
## 2.2 Export of Iron Ore

Goa's Iron Ore industry is wholly dependant on exports. Goa's Iron Ore is often used as a product blend in other countries to make up for the optimal Silica, Alumina content with the ores from other parts of the world. While iron ore exports from the rest of the country had to be canalized through the MMTC with the exception of Kudremukh Iron Ore Ltd., the exports of iron ore from Goa and Redi region were permitted to make direct shipments to Japan, China, South Korea, Taiwan, Middle East, Pakistan and Europe (Ministry of Steel, India). However, since 1996, iron ores belonging to category of under 64% Fe content had been decanalized from the country.

Iron ore exports commenced in the late 40's with around 40 thousand tons of iron ore exported through Goa's Port. The exports witnessed a remarkable jump to about an average of 10 million tons in 1970s and have been rising consistently since then (see Figure 2.4). The last decade recorded an average export of 14.8 million tons of iron ore from Goa. Goa has been the biggest exporters of iron ore of India. Among all the ports of India, Goa has been topped the chart for exporting the maximum share of total exported iron ore of India in the recent years as shown in Table 2.5. In quantity terms share of Goa's export in India has been around 40% for the period of 2006-07 through 2008-09. But on the other hand in value terms its contribution has come down from 35.1% in 2006-07 to 26.9% in 2008-09. It can be because of the low prices of low grade iron ore exported from Goa.

Since Goa is the biggest exporter of low grades of iron ore from the country, it has substantially gained from its export earnings. There has been a tremendous increase in high iron ore prices in the international market in the last few years. In addition to this, there has been a high demand for even the low grade ore coming from China's booming steel industry. The major buyer of Goa's iron ore has been China in last few years. Due to high demand of iron ore in china in past few years Goa's contribution towards India's Iron ore exports have been significantly high.

**Figure 2.4: Decade-wise Average Exports in Million Tons from Goa**




Source: GMOEA website

## 2.3 Employment Structure in Goa

The mining industry has been one of the largest employment generators in the Goan economy. Besides, it generates employment for many other occupations that are dependent on it. The entire inland waterways operators and roughly 71 per cent of total transportation are dependent on the iron ore sector as the prime mover. This sector generates considerable employment opportunities for the skilled as well as the unskilled labour. Besides, the prevailing high unemployment rate of 8.7% of population (20 percent of labour force) makes this a crucial industry segment in Goa's context (NSSO, 2004-05). The nature of employment makes the 'Mining and quarrying' very critical in effacing the unemployment problems of the state.

The sector-wise employment of Goa is estimated and is shown in Table 2.6. The labour force participation rate of Goa for the year 2004 – 05 is 39.8 per cent (Manpower Profile India Yearbook, 2009). On the other hand, the unemployment rate of Goa in urban areas is 8.7% (National Sample Survey Organization, 61st Round, 2004-05). Assuming the population in rural areas to be insignificant in Goa, we estimate the work force percentage of Goa to be 39.8 per cent - 8.7 per cent i.e. 31.1 per cent as the work force percentage. The population of Goa is 1,463,000. Thus the work force of Goa is population*work force percentage i.e., 454,993.

The estimation of the tourism industry's direct and indirect employment benefits for comparison with that of the mining and quarrying industry is given as follows.

In order to estimate the share of tourism industry in Trade, Hotel and Restaurants, we have considered the tourism industry's consumption ratio in accommodation services, food and beverage services and trade as mentioned in Appendix Table 1. We multiply tourism industry's consumption ratios for accommodation services, food and beverage services and trade with their respective weights of employment. Assuming that the weights are 60%, 25%, 15% for accommodation services, food and beverages services and trade, the share of tourism industry stands 63 per cent (.91 * 60% + .1841 * 25% + .22 * 15%) in Trade, Hotels and Restaurants.

Given the employment in trade, hotel and restaurant sector to be 105000 as shown in Table 2.6, the tourism industry accounts for 66,150 (63% of 105,000) work force within Trade, Hotel and Restaurants. The tourism sector also is an important demand factor for the transportation sector. Out of 63,000 employed in the transport sector, 45,000 are employed in transportation specific to Mining and Quarrying (as given in table 2.7). If we assume that the rest of the workforce that are employed in the transport sector in Goa is mainly due to the tourism industry, the tourism can employ a maximum of 18,000 persons.

**Table 2.5: Port-wise Iron Ore Exports from India (2006-2007 to 2008-2009) (Quantity in Lack Tonne; Value: Rs. in Crore)**

| Port | 2006-07 | | 2007-08 | | 2008-09 (Prov.) | |
|---|---|---|---|---|---|---|
| | Quantity | Value | Quantity | Value | Quantity | Value |
| Belekeri | 41.22 (4.3) | 908.13 (4.8) | 45.77 (4.4) | 1,620.72 (4.7) | 18.45 (1.7) | 601.97 (1.7) |
| Chennai | 103.5 (11.0) | 2,343.54 (12.4) | 105.51 (10.1) | 3,724.27 (10.9) | 82.81 (7.8) | 3,910.78 (11.4) |
| Ennore | 17.19 (1.8) | 412.64 (2.1) | 21.94 (2.1) | 822.44 (2.4) | 11.11 (1.1) | 478.85 (1.4) |
| Haldia | 78.49 (8.4) | 1755.06 (9.3) | 95.61 -9.2 | 3,245.35 (9.5) | 85.84 (8.1) | 3,216.01 (9.4) |
| Hazira/Mumbai | 3.15 (0.3) | 101.27 (0.5) | 0.49 (0.1) | 23.69 (0.1) | 2.76 (0.3) | 136.19 (0.4) |
| Kakinada | 38.13 (4.1) | 894.83 (4.7) | 34.62 (3.3) | 1,210.87 (3.5) | 18.26 (1.7) | 799.24 (2.3) |
| Karwar | 14.9 (1.6) | 335.87 (1.7) | 16.86 (1.6) | 576.65 (1.6) | 21.76 (2.1) | 708.22 (2.1) |
| Krishnapatnam | 5.5 (0.6) | 120.93 (0.6) | 19.99 (1.9) | 719.61 (2.11) | 62.4 (5.9) | 2,225.93 (6.5) |
| **Goa** | **405.37 (43.2)** | **6,606.05 (35.1)** | **395.52 (37.9)** | **11,931.23 (34.9)** | **455.89 (43.1)** | **9,172.95 (26.9)** |
| New Mangalore | 52.4 (5.6) | 1,247.35 (6.6) | 81.4 (7.8) | 2,889.78 (8.4) | 74.13 (7.0) | 3,455.24 (10.1) |
| Paradeep | 119.48 (12.7) | 2,786.11 (14.7) | 127.17 (12.2) | 4,267.4 (12.5) | 136.67 (12.9) | 5,727.76 (16.8) |
| Redi Port | 4.3 (0.5) | 85.02 (0.4) | 4.54 (0.4) | 165.47 (0.5) | 5.29 (0.5) | 170.68 (0.5) |
| Vizag | 54.27 (5.8) | 1,239.28 (6.58) | 93.28 (8.9) | 2,902.94 (8.5) | 83.28 (7.9) | 3,432.85 (10.1) |
| **Total** | **937.9 (100.0)** | **18,836.1 (100.0)** | **1,042.7 (100.0)** | **34,100 (100.0)** | **1,058.7 (100.0)** | **34,036.67 (100.0)** |

Note: Share (%) is in parentheses

Source : Lok Sabha Unstarred Question No. 1603, dated on 30.11.2009. http://www.indiastat.com/ForeignTrade/12/IronandSteel/18158/467183/data.aspx

Thus going by approximate calculations for the tourism sector the total employment generated directly and indirectly is 84,150 (18,000+66,150) in the tourism sector.

The employment in the Mining and Quarrying industry is 75,000 (Table 2.7) which is close to the approximate estimates of employment in the tourism sector. Considering that the unemployment in Goa is 8.7%, not having the mining and quarrying industry employing 75,000 would be a considerable economic loss leading to an unacceptable level of unemployment of 13.8 per cent of population (total unemployment of Goa + total employment due to mining and quarrying/Total population). This would be accentuated due to the fact that the manufacturing industry has a limited capacity to absorb employment as the employment/unemployment survey shows.

## Table 2.6: Sector-wise Workforce in Goa in 2004-05

| Major Sectors in Goa | Per 1000 distribution of working persons in Goa* (I) | (I)/1000 | Number of people employed [(I) X Work Force ***] |
|---|---|---|---|
| Agriculture, etc | 48 | 0.048 | 22,000 |
| Mining & Quarrying | 41 | 0.041 | 19,000 |
| Manufacturing | 153 | 0.153 | 70,000 |
| Electricity, water etc | 11 | 0.011 | 5,000 |
| Construction | 144 | 0.144 | 65,000 |
| Trade, Hotel and Restaurant | 232 | 0.232 | 105,000 |
| Transport | 138 | 0.138 | 63,000 |
| Finance, international business, | 31 | 0.031 | 14,000 |
| Pub admin, educn., commerce | 202 | 0.202 | 92,000 |
| **(A)Total Work Force in Goa** | | | **455,000** |
| **(B)Total Unemployment in Goa ( .087** X 1463000)** | | | **127,000** |
| **Total Labour force in Goa (A+B)** | | | **582,000** |

Source : * Report no 515 part - I Chapter Six p.139 National Sample Survey Organization, 61th Round rural population not included as its negligible in Goa.
**Report no 515 part - I Chapter Six p.167 National Sample Survey Organization, 61th Round the rural population not included as its negligible in Goa.
*** Work Force = population (projection population for India 2001-2026, Census of India 2001 p 77)*work force percentage

## Table 2.7: Mining and Quarrying related Employment Distribution in Goa for 2008-09

| | | |
|---|---|---|
| **Mining and Quarrying (Iron Ore)** | | **30,000** |
| Direct | 15,000 | |
| Indirect (Trade, Hotel & Restaurant, Samplers, Ship agents, Ports , Finance, | 15,000 | |
| international business, etc) | | |
| **Transportation specific to Mining and Quarrying** | | **45,000** |
| Total employed in trucks | 36,000 | |
| No of trucks employed in road transportation | 12,000 | |
| Employment per truck | 3 | |
| Total employed in barges | 5,400 | |
| No of Barges | 300 | |
| Employment per Barge | 18 | |
| Supervision (barges) | 600 | |
| Truck repair garages etc | 3,000 | |
| **Total direct and indirect employment due to Mining and Quarrying** | | **75,000** |
| **All other Manufacturing** | | **70,000*** |
| **Total work force** | | **455,000*** |

Source: GMOEA, 2008-09,
* From Table 2.6.

# Input-Output Model as the Appropriate Economic Model to Measure State Level Impact of Iron Ore Mining Industry

CHAPTER THREE

# Input-Output Model as the Appropriate Economic Model to Measure State Level Impact of Iron Ore Mining Industry

The interactions or linkages among different sectors of an economy are of crucial significance in understanding the growth trajectory of any industry. Industries are linked to one another – a fact that should be taken into account while deciding on a development strategy. An increase in demand for one sector's output leads to, apart from increasing output, additional income and employment in that sector plus greater demand for raw materials. This sparks off demand in other sectors with the concomitant increase in output, income and employment in those sectors as well. Therefore, an increase in demand for one sector's output sets up a chain reaction in the economy resulting in increases in output, employment and value added that are multiples of the original sector's stimulus.

The Input-Output table allows the estimation of the direct as well as indirect requirements of producing an additional unit of any sector's output. To quantify the economic impact of increase in output of any one sector, two measures, namely, the Output Multiplier and Employment Multiplier effects are analyzed. In the earlier chapter, we examined the Global supply shock induced effects on the international iron-ore industry and the consequent percolation effect on Goa state economy. In this chapter we look at the basic steps involved in evolving the Flow Matrix, the Coefficient Matrix, Leontief Inverse Matrix to arrive at basic indicators of the impact of the industry at state level by drawing out a Goa I-O Table in 2007-08 prices. Special efforts have been made to project the I-O Table in 2007-08 prices to account for the impact of Global supply shock on the Goa domestic economy. The estimations for output multiplier as well as income multiplier are given in the subsequent sections.

## 3.1 Definition of Output Multiplier

The term "linkage" implies the existence of interdependence among sectors through intermediate consumption or production. Backward linkage of a sector reveals the interrelationship of that particular sector with all other sectors of the economy that supply inputs to it. Policy makers interested in accelerating growth emphasis industries with strong backward linkages, because it is these industries that stimulate production in a large number of additional sectors. Growth in a sector with high backward linkages provides stimulus to other sectors by requiring more inputs. The extent of prevalent backward linkage is measured by the Output Multiplier.

The Output Multiplier, also known as the Leontief Multiplier, is a measure that provides the over all impact of a sector on the output generation in the entire economy as well as for the individual sectors of the economy. It is defined as the total increase in output generated for one unit increase in final demand of a particular sector. Sectors that exhibit strong linkages with other sectors of the economy are found to have high Output Multipliers.

## 3.2 The Concept of Input-Output Table

The I-O table through its Leontief Inverse enables you to arrive at estimates of Output Multiplier as well as Employment Multiplier effects at the state level arising out of an additional output in value terms of the target

industry/sector under examination. This feature of the I-O table was the main catalyst for choosing the I-O model to assess the state level impact in Goa.

### 3.2.1 I-O Table Basic Steps

The seven basic steps followed in this section are briefly stated below:

**Step 1: Flow Matrix** tracing the flow of output from one industry to another and from industries to final users. In the flow matrix, each row shows output allocated according to uses (including final demand), whereas each column shows the costs and profit of producing the output.

**Step 2: Coefficient Matrix** - When flows are converted into ratios column-wise the resultant matrix is the Coefficient Matrix (also known as the A matrix). These fixed coefficient production functions are often called Leontief production functions

**Step 3: Leontief Inverse Matrix** $(I-A)^{-1}$ also known as the Total Requirements Matrix captures the total (Direct and Indirect) input requirements needed to produce one additional unit of output by each industry.

**Step 4: Output Multiplier** is defined as the total increase in output generation for one unit increase of final demand in a particular sector.

**Step 5: Employment Multiplier** has also been specified in man-years of additional employment created for an increased output of Rs. 1 lakh of the concerned sector (at 2007-08 prices)

### 3.2.2 Key Assumptions of the Economic Model as well as the representative database are briefly stated below:

a. Technology matrix which gives input coefficients, ratios of value added to total output etc. that is used in the I-O table, pertains to the I-O table are per norms evolved by the CSO updated to 2007-08 price levels.

b. The multiplier effects (output, employment etc.) when indigenous inputs/efforts are used in export of commodities, is well recognized.

c. Representative Database for the I-O Table: For the Goa state economy, the I-O table divides the Goa state economy into 16 sectors.

### 3.2.3 Input Output Table Flow Matrix – Hypothetical Illustration

To explain the concept, a highly simplified example is shown in Table 3.1, which contains only four industries. Industries shown in rows are producing industries where as those shown in columns are users. For example, row 1, industry 1, indicates that it produced Rs 20 lakh worth of products used within the industry; it produced Rs 65 lakh worth sold to industry 2, Rs 50 lakh worth sold to industry 3 and Rs 10 lakh worth sold to industry 4. These intermediate uses totaled Rs 145 lakh. Final products were valued at Rs 245 lakh so total output was Rs 390 lakh. Similarly industry 3 sold Rs 60 lakh worth of output to industry 2, and so on.

**Table 3.1: Simplified Input-Output Table (Flow Matrix), Value in Rs lakh**

| As Producers | As Users | | | | | | |
|---|---|---|---|---|---|---|---|
| | Industry 1 | Industry 2 | Industry 3 | Industry 4 | Total Inter-mediate Uses | Final Use | Total Use |
| Industry 1 | 20 | 65 | 50 | 10 | 145 | 245 | 390 |
| Industry 2 | 0 | 30 | 0 | 0 | 30 | 260 | 290 |
| Industry 3 | 50 | 60 | 70 | 15 | 195 | 50 | 245 |
| Industry 4 | 40 | 15 | 50 | 70 | 175 | 200 | 375 |
| Total Purchases | 110 | 170 | 170 | 95 | 545 | - | - |
| Value added | 280 | 120 | 75 | 280 | - | 755 | - |
| Total output | 390 | 290 | 245 | 375 | - | - | 1,300 |

Each producer is also user of intermediate goods, and its purchases are shown in the columns of the I-O table. For example, industry 2 bought Rs 65 lakh worth of industry 1 products and also Rs 30 lakh from within the industry, Rs 60 lakh from industry 3 and Rs 15 lakh from industry 4. Total purchases for this industry were Rs 170 lakh. These industries added value of Rs 120 lakh, so total output was valued at Rs 290 lakh. This must be equal to the total output shown in row 2 for industry 2. Each row shows output allocated according to uses (including final demand), whereas each column shows the costs and profit of producing the output. Row 6 gives value-added by each industry and the sum of its entries; if extended to all sectors in the I-O Table of the Indian economy must yield the GDP. In this form the I-O table is also called the **flow matrix**. For the Indian economy, the Central Statistical Organization (CSO) constructs the input-output tables; the latest one just released in 2005 has been obtained for the study (See Section IV).

### 3.2.4 Input Output Table Coefficient Matrix-Hypothe tical Illustration

To turn the input-output matrix into a usable tool for calculating the Cumulative non-VATable Tax Incidence, a crucial assumption is required. If it is assumed that the technology parameters like the ratio of purchases and value added to total production is fixed for every industry as of now and will prevail in future for next 5 years, then this accountant's snapshot of costs becomes an economist's production function with fixed coefficients. It says that for an industry, inputs and costs must expand proportionately with outputs. Table 3.2 can be converted into matrix of ratios, called **input-output coefficients**; this is done in table 3.2. Each column in table 3.2 has been divided through by its total, so that the second column, for example, now gives the ratios of inputs to output for industry 2: each unit requires 0.23 of industry 1 output, 0.10 of industry 2 output, 0.21 of industry 3 output, 0.05 of industry 4 output and 0.41 of value added.

The resulting table of coefficients, known as the **A matrix**, can be seen as a set of production functions for each sector shown in the columns. These fixed coefficient production functions are often called **Leontief production functions**. The elements (coefficients) of I-O tables are usually designated aij; the subscripts referring to the row (i, for input) and column (j) in that order. Thus, $a_{12}$ is the output of sector 1 needed per unit of sector 2 output, a value of 0.23, while $a_{43}$ is the 0.20 unit of sector 4 output needed to produce one unit of sector 3 goods. This matrix is suited to tracing direct incidence of taxes.

### 3.2.5. Input Output Table: Leontief Inverse to Obtain Output Multipliers-Hypothetical Illustration

Thus, for any level of output of the four industries, which we now label $X_1$ through $X_4$, the amount of $X_1$ required would be

$$X_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 + F_1$$

This says that enough $X_1$ must be produced to cover the input needs of each of the producing sectors, given by the input-output coefficients times the level of output, or $a_{ij}X_i$, plus the amount of $X_1$ needed for final demand $F_1$. The same is true for each of the other products, so the complete model is

$$X_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + a_{14}X_4 + F_1$$
$$X_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + a_{24}X_4 + F_2$$
$$X_3 = a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + a_{34}X_4 + F_3$$
$$X_4 = a_{41}X_1 + a_{42}X_2 + a_{43}X_3 + a_{44}X_4 + F_4$$

**Table 3.2: Coefficient Matrix**

| As producers | Industry 1 ($X_1$) | Industry 2 ($X_2$) | Industry 3 ($X_3$) | Industry 4 ($X_4$) |
|---|---|---|---|---|
| Industry 1 ($X_1$) | 0.05 | 0.23 | 0.20 | 0.03 |
| Industry 2 ($X_2$) | 0.00 | 0.10 | 0.00 | 0.00 |
| Industry 3 ($X_3$) | 0.13 | 0.21 | 0.29 | 0.04 |
| Industry 4 ($X_4$) | 0.10 | 0.05 | 0.20 | 0.18 |
| Total Purchases | 0.28 | 0.59 | 0.69 | 0.25 |
| Value added | 0.72 | 0.41 | 0.31 | 0.75 |
| Total output | 1.00 | 1.00 | 1.00 | 1.00 |

$F_1$ through $F_4$ are the final goods required for the economy. The above set of equations may be put in the matrix form as given below:

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix} + \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix}$$

where $X = A X + F$

X= Gross Output Vector

F= Final Demand Vector

A= Technology matrix (also known as direct requirements matrix)

$a_{ij}$ = quantity of good i require directly in the production of one unit of commodity j.

The total (direct and indirect) input requirements needed to produce one additional rupee of output by each industry is obtained from the total requirements matrix.

Using the following identities

$X = (I-A)^{-1} F$

$X = (r_{ij}) F$

Where $r_{ij}$ is known as Leontief inverse or total requirements matrix.

The Total Requirements Matrix is shown in Table 3.3:

**Table 3.3: Leontief Inverse – Total Requirements Matrix-General Formulation**

| | | Producing Industries | | | |
|---|---|---|---|---|---|
| | | Industry 1 | Industry 2 | Industry 3 | Industry 4 |
| Supplying Industries | Industry 1 | $r_{11}$ | $r_{12}$ | $r_{13}$ | $r_{14}$ |
| | Industry 2 | $r_{21}$ | $r_{22}$ | $r_{23}$ | $r_{24}$ |
| | Industry 3 | $r_{31}$ | $r_{32}$ | $r_{33}$ | $r_{34}$ |
| | Industry 4 | $r_{41}$ | $r_{42}$ | $r_{43}$ | $r_{44}$ |
| | Output multipliers | $\Sigma r_{i1}$ where i=1,2,3,4 | $\Sigma r_{i2}$ where i=1,2,3,42 | $\Sigma r_{i3}$ where i=1,2,3,4 | $\Sigma r_{i4}$ where i=1,2,3,4 |

For the hypothetical A matrix given above, the Leontief Inverse is shown in Table 3.4:
The column total gives the output multiplier for that industry.

The Input-Output table has been constructed for Goan economy for the year 2007-08 which is attached in Appendix Table A2-A6.

**Table 3.4: Leontief Inverse – Total Requirements Matrix-Hypothetical Example**

| | | Producing Industries | | | |
|---|---|---|---|---|---|
| | | Industry 1 | Industry 2 | Industry 3 | Industry 4 |
| Supplying Industries | Industry 1 | 1.10 | 0.36 | 0.33 | 0.06 |
| | Industry 2 | 0 | 1.11 | 0 | 0 |
| | Industry 3 | 0.21 | 0.41 | 1.49 | 0.08 |
| | Industry 4 | 0.19 | 0.21 | 0.40 | 1.25 |
| | Output multipliers | 1.50 | 2.09 | 2.22 | 1.39 |

### 3.3 Estimates of Output Multiplier and Employment Multiplier

The linkages among different sections of an economy are of crucial significance in understanding the trajectory of any industry. The significance and potential of any industry can be observed by looking at three important indicators i.e. the output multiplier, the employment multiplier and the degree of forward linkage. The forward linkage occurs when consumption takes place either through production of commodity in the domestic economy or through imports; thus the focus here is mainly on employment multiplier and output multiplier which occurs when backward linkage is established.

#### *Output Multiplier*

The output multiplier traces the backward linkage in producing a commodity, which is important for understanding the trajectory of any industry. The output multiplier can be defined as a total (direct and indirect) increase in output generation for one unit increase of final demand for a particular sector. In the instance of backward linkage, use of a particular commodity induces demand for increased production of inputs which in turn require second stage inputs. These second stage inputs would require further inputs. The geometric progression of "output" at each stage is summed up as a geometric progression to obtain the output multiplier effect. The output multiplier (OM) derived includes the unitary value for the output

#### *Employment Multiplier*

The employment multiplier is also calculated to illustrate the beneficial employment effect if the economy uses domestic inputs/ efforts in execution of exports. Using these employment coefficients and Leontief Inverse Matrix we obtain Employment Multipliers for different sectors.

### 3.3.1 Estimate of Output, Income and Employment Multiplier for Goa 2007-08

Using the values of Output and Income Multipliers from Table 3.5, we can calculate the actual impact of the Goan iron ore industry, in terms of value of output created as well as income generation. In the following table we present the output and income multipliers for the state of Goa based on the 2007-08 I-O tables.

The Mining and Quarrying contributes Rs 174,633 lakhs to the state GDP at current prices at factor cost. The Gross value added to the gross value of output ratio for the Mining and Quarrying industry (primarily iron ore) assumed in the Input-Output table for Goa and in state level GSDP computation is 0.78. Thus, the total value of output in 2007-08 at factor cost is Rs 223,888 Lakhs (This figure is specific to mine head and excludes transport cost, transshipment cost, insurance costs, loading and unloading costs). When accounted at market prices, the value of output per national level norms should be around twice the output at factor cost. This is because entries at factor cost are derived by removing the components of trade and transport margins as mentioned above and net indirect taxes from market prices. Net indirect tax is the difference between the indirect tax paid and subsidy received by a sector of production. Indirect taxes are distinguished as commodity taxes and other indirect taxes paid by the industries on intermediate inputs used in the process of production of industries' output. Since the entire output produced in Mining and Quarrying in Goa is exported, the exported value should give us an estimate of the total value of production. The estimate of total exports for the years 2007-08 is Rs 665,000 lakhs. This would correspond to a production of Rs 332,500 lakhs at factor cost or a value added of Rs 260,000 lakhs rather than Rs 174,633 lakhs. **This shows that the value of contribution from Mining and Quarrying to GSDP based on factor prices by the state government is underestimated by 33% and needs to be reviewed.**

The output multiplier for the mining and quarrying industry at 2007-08 was 1.45, which means that for every unit of output produced in the mining sector, the total output generated in the economy is 1.45. This includes both direct and indirect output generation from all the sectors. The output of Mining and Quarrying industry at factor cost prices in 2007-08 is Rs 332,500 lakhs. Therefore, the total output generated directly and indirectly is 1.45 * 332,500 = Rs 482,000 lakhs.

The employment multiplier measures the direct and indirect employment generated in man years per lakh of output generated. For the mining industry, employment multiplier was 0.41 man-years per lakh of output at 2007-08 prices.

**Table 3.5: The Output, Income and Employment Multiplier for Major Industries of Goa in 2007-08**

| Sector | Output multiplier | | Income multiplier (Value Added per 1 Re output) | Employment multiplier (Man years / Lack of output) |
|---|---|---|---|---|
| | 2003-04 | 2007-08 | | |
| Agriculture | 1.54 | 1.52 | 1.02 | 3.41 |
| Forestry & logging | 1.20 | 1.18 | 0.99 | 0.89 |
| Fishing | 1.36 | 1.34 | 0.99 | 0.48 |
| Mining & quarrying | 1.51 | 1.45 | 0.98 | 0.41 |
| Manufacturing | 2.43 | 2.35 | 0.82 | 0.84 |
| Construction | 2.36 | 2.31 | 0.93 | 0.83 |
| Electricity, gas and water supply | 2.29 | 2.14 | 1.05 | 0.45 |
| Railways | 2.15 | 2.10 | 1.00 | 0.63 |
| Transport by other means | 2.18 | 2.13 | 0.94 | 1.01 |
| Storage | 1.85 | 1.72 | 0.99 | 0.57 |
| Communication | 1.46 | 1.40 | 1.00 | 1.19 |
| Trade, hotels and restaurants | 1.50 | 1.44 | 0.99 | 0.76 |
| Banking & Insurance | 1.39 | 1.31 | 0.99 | 0.22 |
| Real estate, ownership of dwellings and business services | 1.27 | 1.30 | 0.99 | 0.34 |
| Public administration | 1.00 | 1.00 | 1.00 | 0.46 |
| Other services | 1.42 | 1.41 | 0.98 | 0.49 |

Source: Estimated

The income multiplier measures the total direct and indirect value addition due to increase in one unit of output. The income multiplier for Mining and Quarrying industry is 0.98. This means that for every unit of output produced in the industry, the direct and indirect value added generated is 0.98 units in the economy. The total share of iron ore industry at current prices is 10.14% in Goa's GSDP, which does not account for the indirect contribution due to the multiplier effect. Therefore, after accounting for the direct and indirect contribution of Mining and Quarrying to the GSDP, the share of this industry would increase to 0.98/0.78*10.14 = 12.74% at 2007-08 prices. This will go up further to approximately 16.94% if the underestimation of GSDP by Mining and Quarrying as mentioned above is corrected.

# The Environmental Cost due to Iron Ore Industry

CHAPTER FOUR

# The Environmental Cost due to Iron Ore Industry

The magnitude and significance of impact on environment and ecology due to mining depends on the size and scale of mining activity in conjunction with the topography & climatic conditions of the area, the nature of mineral deposits, method of mining & capacity of mines, agricultural activities in the region, forest reserves etc. Figure 4.1 shows various unit operations of iron ore mines and its associated environmental aspects.

Goa along with many other states is now at the stage of great concern for the environmental conservation. The mining industry poses severe challenges to various issues including waste management, pollution of wells in villages, uncontrolled construction and deforestation with little attention given to protect the delicate ecosystem.

## 4.1 Impacts of Mining on Land in Goa

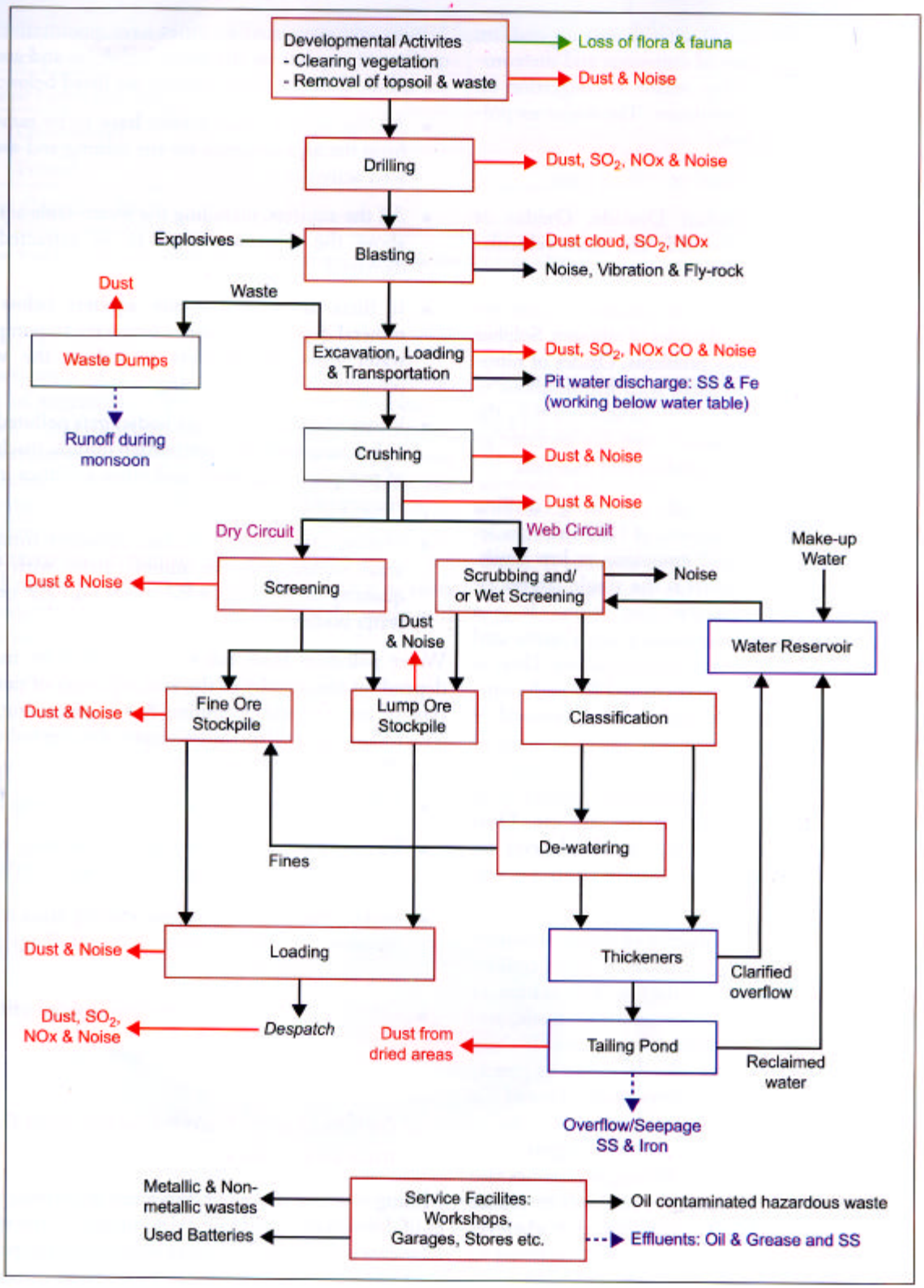
Goa has a total surface area of 370,200 ha out of which approximately 2,000 ha is covered by the mining concessions (about 100 mines) which are active (Forest Department, Government of Goa). The land requirement is basically for expansion of mining pit area, dumps for ore and waste material and tailings pond.

The topography of all the areas to be utilized for mining will obviously be altered. The small sizes of the dumps with steep slopes and the pits changes the landscape of the area, substantially. Most of the waste dumps are step terraced up to 50 meters high with steep slopes due to scarcity of land availability near the mines and as permitted by competent authorities. The wastes are estimated to be generated at a rate of around 45Mt each year and the dumps are either located on flat land or hill slopes. The other challenge is that of the surface run offs from the waste dumps which affect the agricultural lands nearby due to saltation. As per the report on Natural Resource Accounting for Goa by IRADe (2008), around 250ha of agricultural land located close to the mines had been adversely affected during 1980s.

The waste dump rehabilitation has become an integral part of the mining activity of Goa. This is normally been accomplished through surfacing, terracing, final shaping and developing the drainage network and the practice vary from very rudimental to good, depending on the concerned mines. Goa has been successful in managing the dumps efficiently. Some of the mines are using some excellent innovative methods like use of geo-textiles and stone pitching for the slope stabilization. On the other hand, most of the mining companies are adopting plantation on the natural slope dump having more than 30 degree slope angle, without reducing the dump slope to around 20-23 degree. Besides in recent times due to exports demand of grades as low as 50% Fe, such waste dumps are now being marketed.

From a study of satellite imagery (1997) and aerial photographs (1988), it was reported that an area of approximately 300 ha of waste dumps have been partially or fully vegetated. A substantial effort has come from the mining companies themselves in this direction since then. It is estimated that these companies afforest approximately 5 lakh saplings per annum on their waste dumps (Federation of Indian Mineral Industries). Despite the effort there exists a backlog of dump area for rehabilitation. The mining companies are putting effort to reduce the surface run offs from the waste dumps affects to prevent the agricultural lands nearby from saltation. A list of company measures have been mentioned in the sixth chapter.

**Figure 4.1: Environmental Aspect or Iron Ore Mines**




Source: Central Pollution Control Board (CPCB), (2007)

## 4.2 Air Pollution Caused by the Iron Ore Industry in Goa

The air quality in the mining areas mainly depends on the nature & concentration of emissions and meteorological conditions. The other reason is congestion on limited width roads / infrastructure. The major air pollutants from mining include:

- Particulate Matter (Dust) of various sizes
- Gases, such as, Sulphur Dioxide, Oxides of Nitrogen, Carbon Monoxide etc. from vehicular exhaust.

The major gaseous pollutants of concern in iron ore mines are sulphur dioxide and oxides of nitrogen. Sulphur dioxide can cause respiratory problems. Oxides of nitrogen can react in the atmosphere with hydrocarbons to produce photo-chemical smog. In addition to this, the sulphur dioxide and oxides of nitrogen can generate an acid rain that is harmful to vegetation and materials.

Diesel power stations, diesel operating drilling machines, blasting and movement of HEMM/vehicles produce NOx, $SO_2$ and CO emissions at low levels. However, it is the dust which is the single largest air pollutant observed in the iron ore mines. It is a significant nuisance to surrounding land users and potential health risk in some circumstances. Dust is produced from a number of sources and through number of mechanisms such as land clearing, removal of top soil (during opening up of new areas), removal of OB/ore, drilling, blasting, crushing & screening, processing of ore, loading & unloading of material on site & subsequent transport off the site etc. Dust emissions from these operations manly depend on moisture content of the ore and type of control measures adopted.

As mentioned above, concentration of dust is very high in and around the loading & unloading of material on site & subsequent transport off the site. This is because of improper infrastructure, poor width of roads, and inefficient management of construction sites. If these issues are addressed, the air pollution would be greatly reduced from the Mines to the Jetty routes. One of the important needs of the mining companies is to use of higher capacity trucks in order to reduce congestion on roads and thereby air pollution. Mining companies also need to look into other innovative methods to reduce pollution in especially in critical area and wherever possible. These companies are also willing to invest in roads and infrastructure especially dedicated corridors in order to reduce environmental impacts in association with the local community.

## 4.3 Water Pollution Caused by the Iron Ore Industry in Goa

Mining and associated activities have quantitative and qualitative impacts on the water regime in and around the mines. Some of these impacts are listed below:

- All the surface water bodies have to be removed from the area designed for the mining and associated activities.
- All the aquifers, including the water–table aquifer, above the mineral deposit to be extracted are damaged.
- If there are high pressure aquifers below the mineral deposit it becomes necessary to pump the water from the aquifers to reduce the water pressure to facilitate mining.
- Water in the nearby water bodies gets polluted due to leaching from the overburden dumps, discharge of pumped mine water, and other activities in the vicinity of the water bodies.
- During rainy season the run off water from the areas surrounding the mines carries with large quantity of the suspended solids into the nearby water bodies.

Water pollution from the mining operations mainly depend on topography of the area, intensity of rainfall, type of ore, method of mining & ore processing, etc. The following are the major sources of water pollution from the Iron Ore Mines.

- Effluent generated from the Ore Processing Plant
- Pit water discharge from mines operating below water table and discharge of mine water/effluents
- Surface run-off from various mining areas during monsoon e.g., waste/reject dumps, tailings pond seepage/overflow etc.
- Oil and grease pollution from workshops effluent
- Pollution from solid waste disposal sites

## 4.4 Deforestation Caused by the Iron Ore Industry in Goa

Mining is one of the major direct and underlying causes of deforestation and forest degradation in the world. However unlike other activities which results in permanent damage, afforestation can be done on mined out areas. During the exploitation phase, the impacts depend on the method used. In forest zones, the mere

## Table 4.1: Total Area of Forests in Goa

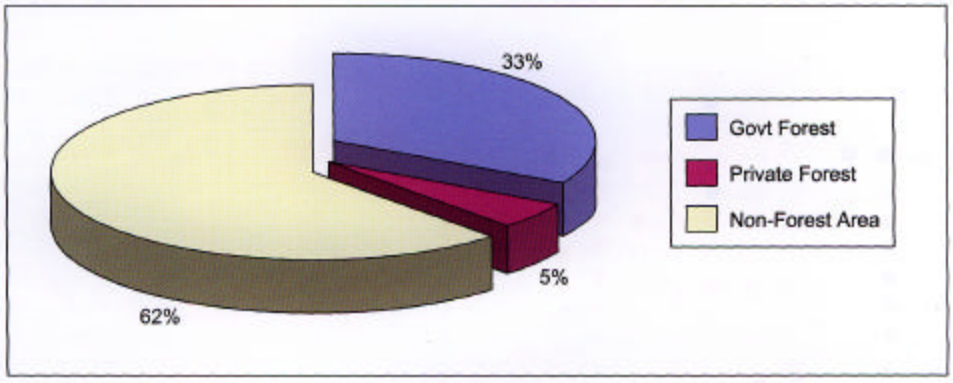
| | |
|---|---|
| Geographical Area (sq. km.) | 3,702 |
| Forest Cover (sq. km.) | 1,424 |
| Government | 1,224 |
| Private | 200 |
| Tree Cover (sq. km.) | 649 |

Source: State Forest Department Goa http://www.goaforest.com/forestsofgoa/forestsofgoa.htm

deforestation of the land with the consequent elimination of vegetation – greater in the case of opencast mines – has short, medium and long-term impacts. Deforestation not only affects the habitat of hundreds of endemic species (many doomed to extinction), but also the maintenance of a constant flow of water from the forests towards other ecosystems and urban centers. Deforestation of primary forests causes a rapid and fluid runoff of rainwater, increasing flooding in rainy periods because the soil cannot contain the water as it does when covered by forest.

Accounting for forest wealth is an important ingredient in creating a framework for analyzing policy trade-offs. IRADe has recently submitted a report titled "Natural Resource Accounting" (2008) that deals primarily with economic and environmental accounting of forests, by and large in accordance with the UN System of Economic and Environmental Accounting, (SEEA 2003). It provides a methodological framework to construct asset accounts and flow accounts of goods and services from the forests. Efforts have been made to quantify value of forest amenities flowing to the economy.

## Figure 4.2: Extent of Forest Area in Goa



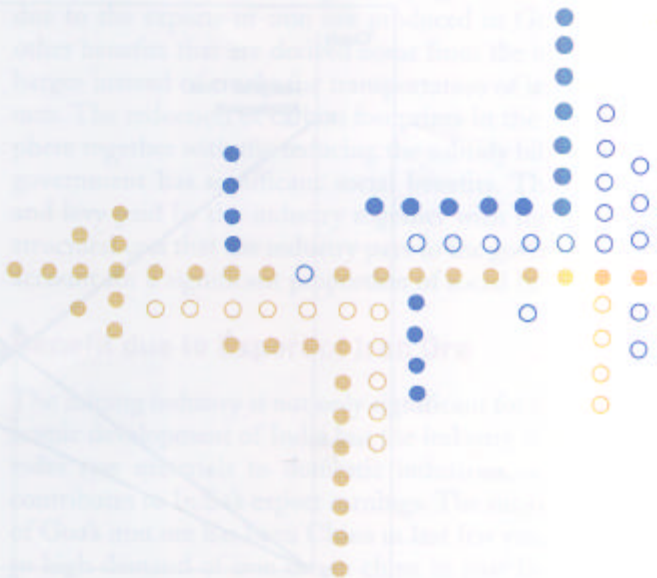

Source: State Forest Department Goa http://www.goaforest.com/forestsofgoa/forestsofgoa.htm

The accounts for Goa forests have described forestry related stocks and flows in terms of land area (under forest), physical volume (of timber and carbon) and finally monetary values. This gives a true estimate of the value of economic activity in the state of Goa. Out of the total geographical area of 3,702 sq km of the state,1224 sq km has been the classified as government forest and around 200 sq kms as private forests which totals to 1424 sq km or ~ 38.4% of the total geographical area (see Table 4.1 and Figure 4.2).

The total growing stock of forest trees is 231000 cubic meters from which various direct consumptive benefits like fuel wood, fodder, timber/salvage, timber etc are obtained. Besides, forest produce comprises of medicinal herbs, prawn culture. For the marketed products like timber, royalty rates fixed up by the department have been used and for the non-marketed products mainly used for self consumption, approximate price of similar goods (e.g. fuel wood, fodder) sold in the other areas is considered. In other words if these people had purchased such products from the market how much they would have paid.

We have estimated the total economic value of Goa forest based on the calculations made by the report published by IRADe. The estimation is shown in Chapter 5 subsequently. The total economic value, the value comes to Rs. **363.26 crores**.

# Social Cost Benefit Analysis



CHAPTER FIVE

# Social Cost Benefit Analysis

In this chapter we explain the concept of cost benefit analysis and estimate the same for the iron ore industry in Goa. The first section briefly describes concept of cost benefit analysis. Section 2 and 3 describes our methodology to estimate benefits and costs of operation of Iron ore mining in Goa. Section 4 summarises the estimated benefits and costs estimated in the form of a table along with the Net present values.

## 5.1 What is Cost Benefit Analysis

The primary purpose of benefit/cost analysis (BCA) is to provide information to stakeholders and decision-makers on the consequences of regulations, administrative actions, or policies that change the status quo. It is a popular approach to making economic decisions of any kind.

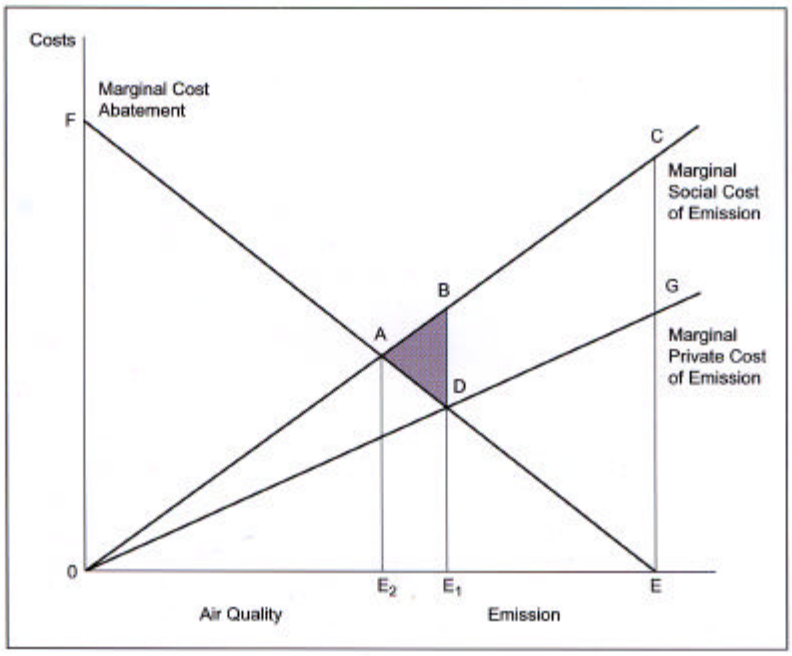
The process involves, whether explicitly or implicitly, weighing the total expected costs against the total expected benefits of one or more actions in order to choose the best or most profitable option. The formal process is often referred to as either Benefit-Cost Analysis BCA.

In this section, we apply an analytical approach where each cost and benefit is converted into monetary terms to give us an estimate of net benefit. These will further be adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their "present value" at the target discount rate.

## 5.2 Theoretical Explanation to Cost Benefit Analysis

Let us consider a case of emission of a pollutant such as suspended particulate matter (SPM) in air. The level of emissions is plotted on the x-axis (one could also look at it from right to left as increasing air quality considering E as the origin) in the Figure 5.1 as shown below.

**Figure 5.1: Demand and Supply of Air Quality and Optimal Emission Level**



The line FE shows marginal cost of abatement (MCA) that would have to be incurred if the emissions were to be reduced. At point O, abatement is complete and there is no emission.

The total cost of this abatement would be the area under the line FE, namely the area FOE.

If emissions are to be restricted to level OE1, i.e., if abatement is to be done to the extent of EE1, the cost of abatement would be area DE1E. The line FE reflects the engineering or technological costs of abatement.

The line OC in the figure shows the marginal social cost of emission. These are the costs borne by the society due to the emission. Social costs associated with emission of a pollutant can be many. For example, suspended particulate matter (SPM) laden air may aggravate respiratory diseases. The incidence of morbidity (sickness) may go up and mortality may also increase as additional deaths are caused by it. There may also be other costs: visibility may be reduced, leading to more accidents or closure of airports, buildings may become dirtier, thus increasing the costs of maintenance and repainting, property value may go down and so on. The line OC reflects these costs. In a sense, this is what those who suffer from this pollution may be willing to pay to reduce the level of pollution. Thus, if the pollution is to be restricted to the level OE1, the society should be willing to pay an amount equal to the area CEE1B.

The third line OG shows the private cost of emission to the emitter herself. It is possible that the emitter herself suffers from the emission. This can happen, for example, if SPM emission by a plant clogs up its own machines and reduces the efficiency of its production processes. In this case, the polluter saves the abatement cost FOE by not doing any abatement but bears the cost OGE, because of the emission OE. It is obvious that the polluter would minimize her costs by abating up to level E1 so that the total costs borne would be equal to the area ODE. The area ABD is therefore, the loss to the society.

By imposing a rising tax on emission we internalize the social cost of emission for the emitter, i.e., these costs now become a part of, internal to, her profit and loss account. If the level of taxes corresponds to line OC, then the social costs are completely internalized. If tax rates correspond to OG, the social costs are only partially internalized. The level of emission would depend on the extent to which costs are internalized. Thus, it would be observed that

OE2 = Optimal level of emissions, when social costs are completely internalized.

OE1 = Emission if some costs are internalized.

OE = Emission when no costs are internalized.

The area OFE is the cost of abatement while OCE measures the value of loss of air quality. The cost of abatement may be an overestimate or an underestimate depending on whether the area OCE is smaller or larger than the area OFE.

However, it is difficult, if not impossible, to estimate the line OC that can give a measure of the optimal emission E2. Ideally the estimate of social cost of accompanying pollution should be accounted. However, one often substitutes the abatement cost approach. As long as the pollution level is at the optimal point when the marginal abatement cost equals marginal social cost (**PO**) then it does not matter whether one uses abatement cost or social cost. The closer is the measure of abatement cost to the social cost, the more accurate estimate we get of optimal level of pollution.

## 5.3 Our Approach to Valuation

In this chapter, all benefits and costs are measured in monetary value (Rs). Though some benefits and costs are usually not expressed in monetary terms, they are converted into monetary terms by estimating the amount of money the recipients of the benefit.

### 5.3.1 Estimation of Benefits

Other than the revenue generated from mining operation of iron ore industry, there are social benefits too that are associated with this industry. One of the social benefits is that of the foreign exchange earned/ saved due to the exports of iron ore produced in Goa. The other benefits that are derived come from the usage of barges instead of trucks for transportation of its products. The reduction of carbon footprints in the atmosphere together with the reducing the subsidy bill of the government has significant social benefits. The taxes and levy paid by the industry together with the infrastructural cess that the industry pays to the government account for a significant proportion of social benefits.

#### Benefit due to Export of Iron Ore

The mining industry is not only significant for the economic development of India but the industry also provides raw materials to domestic industries, and also contributes to India's export earnings. The major buyer of Goa's iron ore has been China in last few years. Due to high demand of iron ore in china in past few years Goa's contribution towards India's Iron ore exports

## Table 5.1: Average Import Duty Rates in India (Total)

| Commodity Group | 1991 -92 | 1992 -93 | 1993 -94 | 1994 -95 | 1995 -96 | 1996 -97 | 1997 -98 | 1998 -99 | 1999 -00 | 2000 -01 | 2001 -02 | 2002 -03 | 2003 -04 | 2004 -05 | 2005 -06 | 2006 -07 | 2007 -08 | 2008 -09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weighted Avg. *** | | | | | | | | | | | | | | | | | | |
| Agriculture | 68.3 | 22.5 | 24.9 | 28.0 | 23.8 | 15.7 | 24.9 | 26.8 | 17.5 | 13.0 | 26.2 | 30.3 | 34.4 | 41.7 | 39.5 | 64.8 | 52.0 | 54.3 |
| Mining | 95.5 | 14.5 | 19.3 | 11.9 | 31.1 | 22.3 | 23.9 | 21.1 | 21.6 | 21.0 | 15.2 | 10.7 | 15.3 | 10.8 | 6.0 | 5.6 | 9.6 | 9.6 |
| Consumer Goods | 114.1 | 86.3 | 66.2 | 62.6 | 43.5 | 38.0 | 34.1 | 41.0 | 41.9 | 57.2 | 50.7 | 48.4 | 57.8 | 43.7 | 31.2 | 29.5 | 22.2 | 12.6 |
| Intermediate Goods | 65.6 | 57.6 | 45.1 | 51.5 | 34.9 | 35.5 | 34.1 | 41.0 | 39.6 | 37.5 | 36.1 | 32.1 | 28.5 | 20.5 | 14.6 | 12.5 | 9.9 | 10.1 |
| Capital Goods | 94.8 | 85.0 | 49.4 | 41.6 | 28.7 | 30.4 | 26.1 | 31.0 | 33.1 | 29.8 | 27.8 | 25.4 | 25.3 | 16.6 | 9.6 | 8.5 | 6.8 | 6.5 |
| | | | | | | | | | | | | | | | | | | |
| **All Commodities** | **77.2** | **62.6** | **45.8** | **47.1** | **32.9** | **33.3** | **30.6** | **36.0** | **36.9** | **37.9** | **29.6** | **25.7** | **26.7** | **18.7** | **12.0** | **11.2** | **10.2** | **9.9** |

Source: Budget documents for customs and tariffs and DGCI&S for imports, 2009.

have been significantly high. In quantity terms, share of Goa's export in India has been around 40% for the period of 2006-07 through 2008-09. And in value terms the contribution of Goa's iron ore exports have gone up from being 6,606.05 cores in 2006-07 to 9,172.95 cores in 2008-09

The weighted tariff of imports in India is 9.9% as per the attached Table 5.1. In other words, foreign exchange is valued as 9.9% premium which brings the demand for foreign exchange in equilibrium to supply. Thus, the shadow exchange rate of foreign exchange is obtained. The premium on foreign exchange is assumed to be 9.9 percent as this is the weighted tariff levied on imports; alternatively this can be viewed as the promotional expense to earn one unit of foreign exchange (Venkatesan Varma, 1998, pg no. 74). It is, therefore assumed that 9.9% of value of exports adds on to the social benefits of the economy (Chadda, 2009, Page no 39).

Based on this assumption the estimate of social benefits due to exports of iron ore from Goa is estimated to be 9.9% of Rs 9,172.95 crores in 2008-09. Thus, the measure comes to Rs 908 crores.

## Taxes paid to State and Central Governments by the Mining Industry

Iron ore industry's contributes a significant amount to the State and Central revenue in the form of taxes. In the year 2008-09, Central government collected over Rs 1,600 Crores from Corporate Tax, Rs 250 crore (export duty paid at 5% towards fine and 10% to lumps, i.e. 15 % has been effective only in April 29, 2010) from Goa's Mining and Quarrying industry. In the same year, the industry paid a total tax of Rs 500 crore approximately to the State government in terms of Royalty paid at 10% ad valorem tax, Barge tax, Road Tax and Road infrastructural cess (see Table 5.2). The total receipts of Goa's government for the year 2008-09 on tax revenue amounted to Rs 2,109 crore (Budget document, Goa 2009-10). Thus approximately 23.7% of tax revenue of Goa government is generated by the Mining and Quarrying industry.

In the estimation of social cost benefit analysis, we consider the contribution of Mining and Quarrying industry exclusively. We consider the royalty paid by the industry, barge tax, road infrastructure cess, the export

### Table 5.2: Taxes paid by Mining Industry to State and Center (Rs crores)

| State Government | Amount |
|---|---|
| **a) State Government** | |
| Royalty paid at 10% ad valorem tax | 300 |
| Barge tax | 12 |
| Road tax | 12 |
| Road Infrastructure cess | 50 |
| VAT, CST | 50 |
| Others (Minor Port, Panchayats, Deadrent, Surface rent, etc.) | 76 |
| **Total** | **500** |
| | |
| **b) Central Government** | |
| This includes export duty at 5% towards fines and 10 % to lumps | 250 |
| Corporate Tax | 1,600 |
| Major Port Charges( Mormugao ) | 150 |
| **Total** | **2,000** |

Source: GMOEA. 2009

duties and corporate tax differentials. The corporate tax differential is obtained as difference of tax that the firms pay out of their profit from Mining and Quarrying industry and the tax the firms would have otherwise paid had they been in some industry, other than Mining and Quarrying. The total corporate taxes is thus multiplied by the difference in ratio of value addition to total output of Mining and Quarrying to that of the average ratio of value addition to total output of other industries as a percentage of ratio of value addition to total output of Mining and Quarrying. The net corporate tax benefit due to the Mining and Quarrying industry is therefore estimated to be Rs 748 Crores.

## Carbon Credit Benefit

A Carbon credit is a generic term meaning that a value has been assigned to a reduction or offset of greenhouse gas emissions. Carbon credits create a market for reducing greenhouse emissions by giving a monetary value to the cost of polluting the air. Transportation of iron ore from the mining site is primarily carried out using barges instead of road transport via trucks. Transport using barges is much cheaper compared to using trucks and other modes of road transport. This additional effort by the iron ore mining industry to reduce pollution is translated into carbon credit benefits.

Every time a barge is used instead of road transport fuel is saved to the order of 0.027 litres per tonne transported per kilometer. Thus, knowing the total tonnes transported and the total kilometers, over which the iron ore is transported, the number of litres saved due to the use of barges is determined. We arrive at the monetary value using the equivalent carbon credit benefits of saving this amount of fuel. The following variables have been used for the estimation of carbon credit. The values have been obtained from energy economy consultants based in Delhi (see Box 5.1 for details).

**a) Fuel Saving in litre/(Tonne.km)**

This is a measure of the fuel saved by transporting iron ore using barges over road transport (trucks). It is measured in litres saved per every tonne of iron ore transported over every kilometer. The total fuel save is estimated to be 0.027 litre/(T.km).

**b) Distance over which Iron Ore is Transported**

These are the lengths of the rivers in Goa over which iron ore is transported. We assume that the full length of the river is used to transport iron ore.

Distance transported in km =

i. 45 km over Mandovi River

ii. 40 km over Zuari River

iii. 18 km over Cumbarjua

Tonnes of iron ore transported in T =

v. 28 Million Tonnes over Mandovi River

vi. 15 Million Tonnes over Zuari River

vii. 1 Million Tonne over Cumbarjua

This is the total tonnes of iron ore transported by barges in Goa. Goa has 3 rivers over which barges are used and we use the values above to determine how much of iron ore is transported over which river.

**c) Total Tonnes*km** = Tonnes of iron ore transported * Distance transported = b)*c) = (28*45+15*40+1*18) * 10^6 = 1,878,000,000 T.km

This is the multiplication of the total tonnes of iron ore transported over the distance it is transported. The units are in Tonne*kilometer (T.km). We will use this value to get the total number of litres saved by using barges instead of trucks. We do this by multiplying this value (Total tonnes.km) into litres of fuel saved per tonne.km of iron ore transported by the barges.

**d) Density of Diesel**

The density varies with the quality between 0.827 kg/l and 0.85 kg/l. This variation has to do with a variation in chemical composition: petroleum diesel contains carbon and hydrogen, biodiesel also some oxygen from the ester. The higher the carbon to hydrogen content, the denser the oil and the more energy it contains. Relatively higher carbon content is found in longer molecules and ring molecules.

In our study, this is measured as .000832 tonnes per litre. We use this value to convert the fuel saved by barges in litres to fuel saved in tonnes.

**e) $CO_2$ equivalent fuel savings**

This value is central to our carbon credit calculation. It provides the link between fuel saved in tonnes (found after (e)) to $CO_2$ equivalents fuel saved again expressed in tonnes.

This is calculated as $CO_2$ equivalent fuel savings per tonne of fuel saved in Tonne and is equal to 3.2 Tonne of $CO_2$ /Tonne of fuel

**f) Euros saved per tonne of $CO_2$**

Finally we know from standard European norms about carbon credit calculations that every tonne of $CO_2$ saved is equivalent to saving 12 Euros. Thus we can convert tonnes of $CO_2$ equivalents saved to Euros saved. This value is 12 Euro/Tonne.

**g) Rs/Euro Conversion Factor**

We then convert this value in Euros to Rupees using the conversion factor above. This gives us the number of Rs saved due to the use of barges in place of trucks which is indirectly due to the iron ore industry in Goa.

The conversion factor we use is = 68 Rs/Euro

## Subsidy Saved on Diesel

The government subsidizes diesel costs to a certain extent. Based on our discussions with energy economy consultants we find that real price per litre of diesel in the market is Rs 41 while the market price per litre is Rs 35. Thus the implicit subsidy that the government pays on diesel is Rs 6.

Due to iron ore exports, barges are used instead of trucks, and a certain amount of diesel subsidy that the government would bear is saved. e calculate this value by finding out the amount of fuel (diesel) saved and converting that into monetary terms using the Rs 6 subsidy that the government provides. The following variables have been used for the estimation of subsidy saved. The values are based on discussions with Energy Economy consultants based in Delhi (see Box 5.1 for details).

**a) Implicit subsidy (Rs/litre)**

This is the subsidy that the government provides for diesel per litre. This is the cost to government avoided by not using trucks.

This value is Rs 6 per litre

**b) Fuel Saving (litre/TKM) = 0.027**

This is the fuel saved by transporting iron ore using barges over road transport (trucks). It is measured in litres saved per every tonne of iron ore transported over every kilometer. We will use this figure and the values: total tonnes of iron ore transported and distance it is transported over to determine the total litres of fuel saved.

c) Total Tonnes*km = Tonnes of iron ore transported * Distance transported = 1,878,000,000 T.km

**Box 5.1: The Estimation of Carbon Credit due to Fuel Saved by the Iron Ore Mining Industry**

The estimation involves the following steps:

**The total litres of fuel saved** = Fuel Saving in litre/Tkm * Total Tonne*km (in litres)
= 0.027124 litre/(Tkm) * 1,878,000,000 T.km
= 50,939,215.7 litres

**Weight of fuel saved** = The total litres of fuel saved * Density of fuel (diesel) (in Tonnes)
= 50,939,215.7 litres * 0.00082 tonnes per litre
= 41,770.16 tonnes

**$CO_2$ equivalent tonnes saved** = $CO_2$ conversion factor * Weight of fuel Saved
= 3.2 Tonne of $CO_2$/Tonne * 41,770.16 tonne
= 13,664.5 Tonne of $CO_2$

**Euros saved** = $CO_2$ equivalent tonnes saved *Euros saved per tonne of $CO_2$
= 13,664.5 *12
= 1,603,974

Conversion of Euro to Rs = 1,603,974 Euros * 68 Rs/Euro = 109,070,234 = Rs 10.9 Crores

Source: Based on discussions with Energy Economy Consultants based in Delhi.

**Box 5.2: The Estimation of Diesel Subsidy saved due to Fuel Saved by the Iron Ore Mining Industry**

i) Implicit Subsidy = Rs 6/litre

ii) Fuel saved in litre/Tkm = 0.027 litre/Tkm

iii) Total Tonnes.km travelled by barges = 1,878,000,000 Tkm

iv) Total fuel saved in litres = fuel saved in litres/Tkm * Total Tonne.km
= 0.027 litre/Tkm * 1,878,000,000 Tkm
= 50,939,216 litres

v) Total Subsidy saved = Implicit Subsidy (Rs/litre) * Total litres saved
= Rs 6/litre * 50,939,216 litres
= Rs 305,635,294

vi) In one line, Total subsidy saved = 6 Rs/litre * 0.027 litre/Tkm * 1,878,000,000 T.km = Rs 305,635,294 = Rs 30.6 crores

Source: Based on discussions with Energy Economy Consultants based in Delhi.

This calculation was done in the previous section where we calculated the carbon credit benefit of the iron ore industry.

d) After we get total number of litres saved by multiplying c) and b), we use this value and the implicit subsidy per litre that the govt pays i.e. Rs 6 per litre to find the total amount that the government would have had to pay to subsidize diesel. This is the amount that the government is saving in subsidies for diesel by using barges instead of trucks.

To note that mining companies are implementing innovative strategies to cut down on transport cost and pollution. One of the mechanisms has been that of the use of ten wheeler trucks instead of six wheeler trucks. The former has twice the capacity than the latter which reduces the number of trucks plying on road. The reduced number of trucks might have a positive influence on diesel subsidy saved. Thus, our estimates of the benefit of diesel subsidy saved may be an underestimate.

## 5.3.2. Estimation of Costs

These are the costs to the environment due to iron ore industries in Goa. The values have been taken from a report on "Natural Resource Accounting for Goa" by the "Integrated Research and Action for Development, New Delhi". These costs were calculated for 2003-2004 in the report. We used the GDP deflators to get estimates at prices as on 2008-2009.

### *Unaccounted Cost of Landfill Sites*

The environmental degradation due to landfill sites that is unaccounted in the national accounts is Rs.11 Crores. We assume that this is primarily due to the mining industry in Goa as it is too small a value to make much difference in our cost benefit analysis.

### *Avoidance Cost*

The avoidance cost for the solid waste management is 0.4 Crores and we assume again that this is primarily due to the mining industry in Goa as it hardly makes any difference in our calculation considering its small value.

### *Air Pollution due to Iron Ore Mining*

IRADe estimated the pollution load for each firm and industrial sector. Since actual information of this nature does not exist, it estimated this information using data on pollution intensities (effluent/emission per unit of output) from the World Bank Industrial Pollution Projection System (IPPS) database. Industrial output data by sector was collected from the official Annual Survey of Industry (ASI) in India. The cost of pollution abatement was estimated using estimates of average abatement cost expressed in terms of US$ (1,993 prices) per ton of pollutant reduced from the same World Bank IPPS database. This was then converted to 2000-01 rupees/ton. However, estimation

of air pollution using this methodology has some inherent limitations.

The total industrial air pollution that was estimated using the above calculation refers to environmental degradation that causes loss of income due to industrial air pollution. The total value estimated was Rs.517 crores for 2008-09. We have used this value of industrial air pollution (Rs. 517 crores) from the report to estimate the air pollution caused by the mining industry.

Air pollution due to Iron Ore mining is considered to be approximately 10% of the total industrial air pollution in Goa. This is because the mining industry only occupies < 3% of the total area in Goa. Pollution caused by industries in an area can't exceed more than 3 times the area occupied, thus we arrive at the figure of 10% of total industrial air pollution.

Since we attribute 10% of this to the mining industry the value comes to Rs 51.7 Crores.

### *Deforestation Costs*

This is the cost to the environment due to deforestation in Goa. The estimation is based on the methodology proposed by the report published by IRADe. They assume that the economic value of forests in Goa excluding eco tourism value, carbon sink and watershed benefits as the cost to the environment due to deforestation. We find the economic value of forests in Goa on account of benefits such as carbon storage, timber production, non-timber forest products and other values of biodiversity including eco-tourism associated with forests to compute the net economic value. This does not take into account the afforestation made by the mining companies for lack of authenticated data.

The Total Economic Value of Goa forest comes out to be Rs. 2,925.93 crores (as explained in Appendix Table A7.1 and A7.2). The total economic value of Goa forest less the indirect benefits of the eco-tourism value, carbon sink, watershed benefits the value comes to Rs.363.26 crores (Table 5.3) in 2004-05 prices . We used the GDP deflators to get the updated value at 2008-09 prices and estimate the economic value of forests at 2008-09 prices as Rs. 467.62 crores.

### 5.3.3 The Benefit Cost Table

The table below gives the summary of all our cost benefit analysis mathematically. We have excluded the road tax and have incorporated the corporate tax differentials to account for benefits that are due to the mining industry. First we see the benefits and then the costs in Table 5.4.

Thus it is clear that the overall the benefits outdo the costs to the environment by Rs 1,842.2 Crore in 2008-09 which is a huge margin.

## 5.4 The Present Value of Net Benefits of Iron Ore Industry

Since we have taken into account abatement costs in this analysis, this can be interpreted as saying that costs associated with giving up the iron ore industry in Goa (Opportunity Cost) would be greater by Rs 1,842.2 Crore per year than costs to the environment associated with running the industry. If we assume the same net benefit every year for the next 25 years and a discount rate of 12 percent (which is the social discount rate generally used to evaluate projects by international and national agencies like the Planning Commission etc.) the Net Present Value of the opportunity cost of giving up the iron ore industry is greater than the environmental cost of the iron ore industry by Rs 1,4449 Crores.

**Table 5.3: Economic Value of Forest**

| Sl.No. | Values of Forests of Goa | Monetary Value (Rs. In crores) |
|---|---|---|
| 1 | Total Economic Value | (+)2,925.93 |
| 2 | Watershed Benefits | (-)2,003.24 |
| 3 | Eco-tourism | (-)396.29 |
| 4 | Carbon sink | (-)148.60 |
| 5 | Fodder (70%) | (-)14.53 |
| 6 | Economic Value of forest of Goa | 363.26 crores |

Source: computed using Appendix Table 7

**Table 5.4: Estimates of Social Costs and Benefits of Mining industry in Goa (per annum)**

| Costs (2008-09) | Value (Crores Rs) |
|---|---|
| **1. Benefits** | |
| Carbon Credit Benefit | 10.9 |
| Subsidy saved on diesel | 30.6 |
| 9.9% of Total exports (Rs 9,172.95 crore) of Iron Ore from Goa | 908 |
| | |
| **Tax paid to State and Central government** | |
| **a) State government** | |
| I. Royalty paid at 10% ad valorem tax, | 300 |
| II. Barge Tax | 12 |
| III. Road Infrastructure cess | 50 |
| **b) Central Taxes** | |
| I) Central Government Includes export duty at 5% towards fines and 10 % to lumps. | 250 |
| II) Corporate income tax differentials | 748 |
| **Total Benefits** | **2,309.5** |
| | |
| **2. Loss of Income due to Environmental Degradation** | |
| Unaccounted Cost of Landfill sites | 14.1 |
| Avoidance Cost | 0.5 |
| Air Pollution due to Iron Ore Mining (10% of Total) | 66.5 |
| | |
| **Accumulated Depreciation of Environmental Capital** | |
| Deforestation | 467.3 |
| | |
| **Total Environmental Cost** | **548.4** |
| | |
| **Net Benefits (Total Benefits – Total costs)** | **1,842.2** |

Source: Estimated

## 5.5 The Net Present Value of Net Social Benefits

The cost benefit analysis clearly shows that the social benefits far outweigh the environmental costs of operation of the mining industry in Goa.

The social cost benefit analysis gives an estimate of net present value of the net social benefit from the Iron Ore Mining Industry to the State to be Rs 1,842.2 crores per annum. Thus, the positive contribution further reinforces our argument that mining industry should continue to operate in Goa. However, mining operations need to have further environmental safeguards in order to maximize net social benefits to the extent feasible.

**NPV Calculation**

NPV = 1,842.2/(1+.12) + 1,842.2/(1+.12)^2 + 1,842.2/(1+.12)^3 … + 1,842.2/(1+.12)^25

= Rs 14,449 Crores

Source: Estimated NCAER 2010.

# Government Policies and Corporate Social Responsibilities

CHAPTER SIX

# Government Policies and Corporate Social Responsibilities

Given the fragility of the Goan ecosystem, the Government has felt the need to implement certain policy measures to maintain the balance of the same. The government of Goa has prepared a broad based regional plan for the perspective horizon year. To accomplish the preparation of the regional plan in a time bound manner, the government has appointed a committee called "Task Force" for the Regional Plan for Goa, 2012 AD. The RPG-21 Task Force (2007) in their report has suggested a few policy measures to reduce the damage caused by mining. Besides, many other reports have been documented their recommendations to the government to check mining operations in Goa.

## 6.1 Recommendations by Various Research Studies

While recognizing the huge economic pressure driving the opening of new mines in the state, the RPG- 21 Task Force has recommended that mining should be allowed in the 1km safety zone around national parks and wildlife sanctuaries. Further no new proposals for forest clearance may be entertained in accordance with the forest department's position that land is not available for compensatory aforestation. The RPG-21 Task Force has also suggested that Dewatering should be banned to protect the water table; Unloading points of ore on river banks shall be beyond CRZ line or they need approval from the GCZMA.

The Pollution Control Board, in the Draft Mineral Policy Report 2005 too has come up with few recommendations. The report concluded that Mining should not be undertaken in forest land for which forest clearance / permission has not been entertained. A plan of conservation of endangered flora and fauna in and around the mine should be prepared and implemented in consultation with the State Forest Department. The use of geo textiles for dump stabilization should be taken up in the critical areas. Catch drain and siltation ponds, of appropriate size, gully plugs and check dams should be constructed to arrest silt and sedimentation flows from the mining operation.

In the Policy Report 2005 Pollution Control Board has also recommended that water harvesting should be undertaken in and around mining area and regular monitoring of ground water level and quality should be carried out by establishing a network of existing wells and construction of new piezometers at suitable locations in project area.

The TERI AEQM Plan for the mining belt of Goa (1997) recommends urgent stocktaking of areas affected by mining needs. According to the report, ore traffic should by-pass villages; social conditions of the people in the mining villages should be improved and the mining companies should upgrade existing water supply, sanitation facilities and provide up to date health facilities in the mining belt.

The mining companies are also suggesting dedicated corridors away from human settlement, and such routes need to be addressed by the Government on priority. There is also a need to dredge the waterways so as to make transport through the riverside system more effective. Feasibility of tapping necessary complimentary investments from mining operators needs to be explored.

## 6.2 Action Taken by the Mining Companies in Goa – Corporate Social Responsibilities

Mining, being a site industry, needs to carry out its operations where minerals are present and necessary approvals are required for the same. Apart from mineral exploration, one of the main functions of the Indian Bureau of Mines is conservation and development of minerals and protection of the environment. It has recognized that the challenge of the Goan mining industry

is to maintain minimal pollution levels, along with optimal utilization of minerals.

The mining industry has responded to this by taking up a number of measures for the sustainable growth of the industry. Most of the existing mining industries have taken specific measures in this direction.

The following section outlines some of the major steps taken by various mining companies, in terms of water conservation, aforestation and pollution control measures.

### 6.2.1 Environment Protective Measures

- Exhaustive exploration is carried out to limit breaking of ground.
- Concurrent backfilling and reclamation is being practiced to ensure maximum coverage of worked out pit area by waste followed by Green Belt development.
- Heavy duty Ripper Dozers are preferred instead of drilling and blasting to control noise & Ground vibration. Drilling & Blasting is occasional and limited to removal of only very hard formations.
- Matured waste dump areas are regularly brought under plantation.
- The waste dumps are suitable terraced with proper height & angle of slopes. Dumps are terraced not more than 10 – 15 meter height in each stage
- All the employees working in the mines are provided with personal protective equipments (PPE), considering the safety factors.

### 6.2.2 Air Pollution Control Measures

To control the Dust, SPM/RPM, gaseous emissions generated during mining and haulage of ore and waste, the following steps are taken:

- Measures like sprinkling of water, plantation are undertaken to control dust and suspended particulate matter on account of mining.
- Part of the mine road leading to the main haulage road is asphalted.
- Motor Grader is used to keep mine road in shape to avoid excessive dust generation.
- Wet drilling is practiced for blast holes used for blasting.
- Transport vehicles are not overloaded and ore transport trucks are covered by tarpaulin to prevent spillage.
- Daily maintenance and periodic preventative maintenances of Heavy Eart Moving Machinery (HEMM) is under taken.
- Voluntary initiatives for road repairs/infrastructure development undertaken

### 6.2.3 Top Soil Conservation

Topsoil, wherever encountered, is separately collected, stacked and utilized for plantation. Quality of soil in core and buffer zone areas is periodically monitored. All soil conservation measures like gully plugging, stone pitching; garland drains are made during monsoon. Retaining wall and garland drains are constructed at the dump bottom to arrest silt load and minimize soil erosion. Companies in consultation with environmental research institutes like TERI (The Energy and Resource Institute, New Delhi) have undertaken a project of soil conservation and plantation on degraded land. Soil amendments such as Gypsum, cow dung and mycorrhizal solutions are used for better growth of the local plant species on dumps

### 6.2.4 Plantation

Extensive plantation is done to prevent Noise, Air & Water pollution and Land degradation. Many companies have established their own nursery to raise large number of saplings and develop suitable species to be grown over iron ore rejects. Nursery helps in providing saplings for extensive plantation every year around all its mines in Goa. This measure has enriched the afforestation programmes by providing rich diversity in raising different indigenous and exotic species. Utmost care is taken to select the species, which are locally growing in order to meet Biodiversity conservation

- Over 5 lac saplings are planted every year of most suited tree species.
- Plantation local fast growing species like Bombex (silk cotton), Mecharanga (Chandivdo), Bamboo, Trema (Charcoal tree), Arcocarpos, are preferred to plantation of acacia.
- Commercially important species of plants like cashew, Jatropha, Pongemia & Bixa etc. are planted for the benefit of the local people. Medicinally important plants like Rauwolfia (Sarpgandha), Alstonia (Devils tree), Emblica (Amla), Mimusopes (bakul), Pterocarpous (Raktchandan), Annona (Sitafal), Syzigium (Jamun), Cassia (Amaltaash) etc. are planted on the dump.
- Plantation of legume herbs like Stylosanthus hamata and scabra and trees like glericidia have

helped to enrich the dump soil with nitrogen and quicker replacement of natural grass species.

### 6.2.5 Mineral Conservation

Sub grade and low grade minerals are carefully segregated while mining and stacked separately with adequate protective measures to prevent wash-off or erosion.

### 6.2.6 In Addition to above following Protective Measures are taken

- At the toe the dump, construction of parapet/boulders wall. Strong tow walls are provided at the dump bottom to arrest silt during monsoon, top surface of the dump is kept sloping towards the centre of the dump and rain water failing on the dump top is brought down through garland drains
- Contour trenches of 1 mt, depth.
- Systematic drainage system for diverting the surface run-off during monsoon.
- Pitching to avoid soil erosion.
- Desitling/maintenance of setting pounds.
- Monitoring and analyzing the quality of water.

The major mining companies have floated the Mineral Foundation of Goa which undertakes socio-economic projects within the mining belt of Goa since 2001 onwards. Besides, various roads, infrastructure development, construction of bridges are undertaken jointly through the Goa Infrastructural Development Co. Pvt. Ltd., an initiative of the Mining Companies in Goa. At other times, mine specific projects are carried by respective mining companies in consultation with nearby Panchayats etc, wherever possible.

# Concluding Remarks

CHAPTER SEVEN

# Concluding Remarks

## 7.1 The Relevance of the Study; Structural Changes in the Iron Ore Industry

The contribution of this industry in terms of GDP has been controversial based on its measurement at 1999-00 constant prices as the major structural change in the international iron ore market occurred in February 2008. This implies that the role of the iron ore sector in the Goan economy would be quite significant if GDP iron ore share is assessed at constant post 2008 prices (or at current prices ). For instance, the share of mining and quarrying in Goa's GSDP at current prices would be 10.1 per cent while the share in terms of constant 1999-00 prices would be 4.8 per cent (Bulk of mining and quarrying in Goa comprises of the Iron Ore sector's contribution). Therefore, assessment of the iron ore sector role in constant 1999-00 prices would not be an appropriate one and could be an understatement.

The report traces the structural changes in the international Iron Ore market through an analysis of time series of international prices. The structural change in the domestic iron ore market is assessed by the multiple regression model with dummy slope variable assigned in 2008.

## 7.2 Iron Ore Mining Industry's Contribution to Employment Opportunities in Goa

The mining industry generates considerable employment opportunities for skilled as well as unskilled labour. Based on the employment and unemployment NSSO study, the unemployment in Goa is around 22 per cent of labour force (8.7 per cent of the population). The direct and indirect employment in the Iron Ore and allied sectors (indirect employment stimulated by mining) such as transportation etc. works out to be 13 per cent of labour force (5.1 per cent of population).

The opportunity cost of not having the Iron Ore Mining Industry in terms of employment would be very significant with unemployment levels hitting 13.8 per cent of population.

## 7.3 Underestimation of Factor Cost Computation in the Iron Ore Mining Industry

The Mining and Quarrying contributes Rs 174,633 lakhs to the state GDP at current prices at factor cost as per government statistics. This figure is specific to mine head and excludes transport cost, transshipment cost, insurance costs, loading and unloading costs. When accounted at market prices, the value of output per national level norms should be around twice the output at factor cost. This is because entries at factor cost are derived by removing the components of trade and transport margins as mentioned above and net indirect taxes from market prices. Net indirect tax is the difference between the indirect tax paid and subsidy received by a sector of production. Indirect taxes are distinguished as commodity taxes and other indirect taxes paid by the industries on intermediate inputs used in the process of production of industries' output. Assuming that the entire production is exported, the estimate of total exports by the Mining and Quarrying industry for the years 2007-08 is Rs 665,000 lakhs. This corresponds to a value added of Rs 260,000 lakhs. This shows that the value of contribution from Mining and Quarrying to GSDP based on factor prices by the state government is underestimated by 33% and needs to be reviewed

## 7.4 Share of Iron Ore Industry in GSDP at Current Prices with and without Multiplier Effects

The total share of iron ore industry at current prices is 10.14% in Goa's GSDP in 2007-08, which does not account for the indirect contribution due to the multiplier effect. If the multiplier effect is included, the share of this industry would increase to 12.74% at current prices.

This will go up further to approximately 16.94% if the underestimation of GSDP by Mining and Quarrying as mentioned above is corrected.

## 7.5 Net Present Value of Benefits of Iron Ore Industry

Since we have taken into account abatement costs in this analysis, this can be interpreted as saying that costs associated with giving up the iron ore industry in Goa (Opportunity Cost) would be greater by Rs 1,842.2 Crore per year than costs to the environment associated with running the industry. If we assume the same net benefit every year for the next 25 years and a discount rate of 12 percent (which is the social discount rate generally used to evaluate projects by international and national agencies like the Planning Commission etc.) the Net Present Value of the opportunity cost of giving up the iron ore industry is greater than the environmental cost of the iron ore industry by Rs 14,449 Crores.

### *The Present Value of Net Social Benefits*

**NPV Calculation**

NPV = 1,842.2/(1+.12) + 1,842.2/(1+.12)^2 + 1,842.2/(1+.12)^3 ... + 1,842.2/(1+.12)^25

= Rs 14,449 Crores

Source: Estimated NCAER 2010.

The cost benefit analysis clearly shows that the social benefits far outweigh the environmental costs of operation of the mining industry in Goa.

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# Appendix Tables

# Appendix Tables

## Table A1: Tourism Industry Ratios

| Industries | Inbound Tourism Consumption | Domestic Tourism Consumption | Outbound Tourism Consumption | Total Tourism Consumption |
|---|---|---|---|---|
| **(A) Tourism Characteristic Products** | | | | |
| Accommodation services | 0.4866 | 0.4307 | - | 0.9173 |
| Food and beverage serving services | 0.0672 | 0.1169 | - | 0.1841 |
| Passenger transport services | | | | |
| - Railway | 0.0099 | 0.2844 | - | 0.2943 |
| - Road | | | | |
| Buses | 0.0055 | 0.6206 | - | 0.6261 |
| Other mechanised vehicles | 0.0016 | 0.0247 | - | 0.0263 |
| Non-mechanised road transport | 0.0022 | 0.8958 | - | 0.8980 |
| - Water | 0.0079 | 0.0140 | - | 0.0219 |
| - Air | 0.4358 | 0.5024 | - | 0.9382 |
| Transport equipment rental | 0.5825 | 0.1681 | - | 0.7506 |
| Travel agencies and similar | 0.3422 | 0.6133 | 0.0009 | 0.9563 |
| Other recreational and entertainment activities | 0.4547 | 0.0352 | - | 0.4898 |
| | | | | |
| **(B) Tourism Related Products** | | | | |
| Clothing and garments | 0.0333 | 0.1273 | 0.0613 | 0.2219 |
| Processed food | n.a. | 0.0213 | 0.0072 | 0.0286 |
| Tobacco products | n.a. | 0.0184 | 0.0024 | 0.0208 |
| Alcohol | n.a. | 0.0022 | 0.0012 | 0.0034 |
| Travel related consumer goods | 0.0518 | 0.0906 | 0.0123 | 0.1547 |
| Footwear | n.a. | 0.0536 | 0.0232 | 0.0769 |
| Toiletries | n.a. | 0.0266 | 0.0116 | 0.0382 |
| Gems and jewellery | 0.0352 | 0.1063 | 0.0097 | 0.1511 |
| Medicines and health related items | n.a. | 0.0826 | 0.0173 | 0.0998 |
| Printing and publishing | 0.0113 | 0.0104 | 0.0062 | 0.0279 |

Source: NCAER Tourism Satellite Account Report.

## Table A2: Input-Output Matrix for Goa, 2007-08

| Sector | Agri-culture | Forestry & logging | Fishing | Mining & quarry-ing | Manufac-turing | Construc-tion | Electr-icity, gas and Water supply | Railways | Trans-port by other means | Storage | Commun-ication | Trade, hotels and restau-rants | Bank-ing & Insur-ance | Real estate, ownership of dwellings and business services | Public admini-stration | Other ser-vices |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 14,958 | 0 | 7 | 0 | 51,334 | 1,957 | 194 | 0 | 3,902 | 0 | 0 | 7,608 | 19 | 0 | 0 | 122 |
| Forestry & logging | 4 | 2 | 0 | 0 | 3 | 843 | 12 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 0 | 0 |
| Fishing | 2 | 0 | 587 | 0 | 570 | 0 | 1 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 |
| Mining & quarrying | 2 | 0 | 0 | 37 | 15,777 | 11,034 | 10,677 | 12 | 0 | 0 | 0 | 102 | 0 | 2 | 0 | 1 |
| Manufacturing | 6,126 | 40 | 4,210 | 9,178 | 643,474 | 72,199 | 11,659 | 1,783 | 90,493 | 63 | 873 | 9,346 | 4,355 | 1,443 | 0 | 4,548 |
| Construction | 551 | 21 | 0 | 461 | 14,772 | 7,441 | 1,820 | 900 | 2,233 | 39 | 104 | 908 | 1,245 | 5,150 | 0 | 885 |
| Electricity, gas and Water supply | 779 | 1 | 0 | 2,486 | 40,127 | 4,137 | 15,963 | 605 | 2,098 | 119 | 127 | 1,471 | 1,260 | 272 | 0 | 140 |
| Railways | 230 | 4 | 23 | 702 | 14,971 | 1,333 | 2,042 | 327 | 736 | 4 | 10 | 120 | 469 | 46 | 0 | 41 |
| Transport by other means | 898 | 28 | 363 | 1,004 | 33,974 | 6,828 | 1,277 | 41 | 6,970 | 11 | 38 | 3,634 | 1,304 | 162 | 0 | 563 |
| Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 58 | 0 | 0 | 771 | 0 | 0 | 0 | 0 |
| Communication | 16 | 2 | 0 | 177 | 3,981 | 159 | 211 | 3 | 2,541 | 0 | 92 | 295 | 1,303 | 213 | 0 | 153 |
| Trade, hotels and restaurants | 5,039 | 15 | 560 | 1,376 | 152,496 | 29,059 | 7,791 | 159 | 35,877 | 16 | 120 | 6,097 | 3,770 | 1,165 | 0 | 1,966 |
| Banking & Insurance | 489 | 3 | 155 | 1,251 | 32,845 | 7,369 | 2,873 | 48 | 4,413 | 21 | 15 | 4,958 | 8,826 | 346 | 0 | 774 |
| Real estate, ownership of dwellings and business services | 0 | 0 | 0 | 0 | 0 | 0 | 68 | 0 | 0 | 0 | 0 | 565 | 322 | 4,206 | 0 | 1,044 |
| Public administration | 143 | 28 | 0 | 1,530 | 18,505 | 36 | 112 | 128 | 10,252 | 19 | 24 | 373 | 257 | 1,568 | 0 | 2,231 |
| Other services | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Input** | **29,238** | **143** | **5,906** | **18,202** | **1,022,828** | **142,395** | **54,699** | **4,007** | **159,574** | **292** | **1,405** | **36,309** | **23,129** | **14,574** | **0** | **12,469** |
| **GVA** | **70,328** | **1,394** | **31,527** | **64,699** | **390,627** | **74,306** | **43,124** | **4,320** | **120,400** | **528** | **6,194** | **111,496** | **102,112** | **72,257** | **53,696** | **41,616** |
| **Total Output (=GVA+Total Input+NIT)** | **96,843** | **1,539** | **36,921** | **83,086** | **1,576,146** | **217132** | **91,094** | **7.987** | **279,666** | **822** | **7,463** | **147,823** | **125470** | **86885** | **53,696** | **54,113** |

## Table A3: Input-Output 'A' Matrix for Goa, 2007-08

| Sector | Agri-culture | Forestry & logging | Fishing | Mining & quarry-ing | Manufac-turing | Construc-tion | Electr-icity, gas and Water supply | Railways | Trans-port by other means | Storage | Commun-ication | Trade, hotels and restau-rants | Bank-ing & Insur-ance | Real estate, ownership of dwellings and business services | Public admini-stration | Other ser-vices |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 0.1545 | 0.0000 | 0.0002 | 0.0000 | 0.0326 | 0.0090 | 0.0021 | 0.0000 | 0.0140 | 0.0000 | 0.0000 | 0.0515 | 0.0001 | 0.0000 | 0.0000 | 0.0023 |
| Forestry & logging | 0.0000 | 0.0014 | 0.0000 | 0.0000 | 0.0000 | 0.0039 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Fishing | 0.0000 | 0.0000 | 0.0159 | 0.0000 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Mining & quarrying | 0.0000 | 0.0000 | 0.0000 | 0.0005 | 0.0100 | 0.0508 | 0.1172 | 0.0015 | 0.0000 | 0.0000 | 0.0000 | 0.0007 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Manufacturing | 0.0633 | 0.0258 | 0.1140 | 0.1105 | 0.4083 | 0.3325 | 0.1280 | 0.2232 | 0.3236 | 0.0768 | 0.1170 | 0.0632 | 0.347 | 0.0166 | 0.0000 | 0.840 |
| Construction | 0.0057 | 0.0139 | 0.0000 | 0.0055 | 0.0094 | 0.0343 | 0.0200 | 0.1127 | 0.0080 | 0.0476 | 0.0139 | 0.0061 | 0.0099 | 0.0593 | 0.0000 | 0.0164 |
| Electricity, gas and Water supply | 0.0080 | 0.0007 | 0.0000 | 0.0299 | 0.0255 | 0.0191 | 0.1752 | 0.0758 | 0.0075 | 0.1452 | 0.0170 | 0.0099 | 0.0100 | 0.0031 | 0.0000 | 0.0026 |
| Railways | 0.0024 | 0.0024 | 0.0006 | 0.0084 | 0.0095 | 0.0061 | 0.0224 | 0.0409 | 0.0026 | 0.0044 | 0.0014 | 0.0008 | 0.0037 | 0.0005 | 0.0000 | 0.0008 |
| Transport by other means | 0.0093 | 0.0185 | 0.0098 | 0.0121 | 0.0216 | 0.0314 | 0.0140 | 0.0051 | 0.0249 | 0.0130 | 0.0051 | 0.0246 | 0.0104 | 0.0019 | 0.0000 | 0.0104 |
| Storage | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0052 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Communication | 0.0002 | 0.0011 | 0.0000 | 0.0021 | 0.0025 | 0.0007 | 0.0023 | 0.0004 | 0.0091 | 0.0000 | 0.0124 | 0.0020 | 0.0104 | 0.0025 | 0.0000 | 0.0028 |
| Trade, hotels and restaurants | 0.0520 | 0.0095 | 0.0152 | 0.0166 | 0.0968 | 0.1338 | 0.0855 | 0.0199 | 0.1283 | 0.0191 | 0.0161 | 0.0412 | 0.0300 | 0.0134 | 0.0000 | 0.0363 |
| Banking & Insurance | 0.0050 | 0.0017 | 0.0042 | 0.0151 | 0.0208 | 0.0339 | 0.0315 | 0.0060 | 0.0158 | 0.0257 | 0.0021 | 0.0335 | 0.0703 | 0.0040 | 0.0000 | 0.0143 |
| Real estate, ownership of dwellings and business services | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0007 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0038 | 0.0026 | 0.0484 | 0.0000 | 0.0193 |
| Public administration | 0.0015 | 0.0179 | 0.0000 | 0.0184 | 0.0117 | 0.0002 | 0.0012 | 0.0160 | 0.0367 | 0.0234 | 0.0033 | 0.0025 | 0.0021 | 0.0181 | 0.0000 | 0.0412 |
| Other services | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **Total Input** | **0.3019** | **0.0929** | **0.1600** | **0.2191** | **0.6489** | **0.6558** | **0.6005** | **0.5016** | **0.5706** | **0.3552** | **0.1882** | **0.2456** | **0.1843** | **0.1677** | **0.0000** | **0.2304** |
| **GVA** | **0.7262** | **0.9058** | **0.8539** | **0.7787** | **0.2478** | **0.3422** | **0.4734** | **0.5408** | **0.4305** | **0.6422** | **0.8299** | **0.7543** | **0.8138** | **0.8316** | **1.0000** | **0.7691** |
| **Total Output** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |

## Table A4: Input-Output 'I' Matrix for Goa, 2007-08

| Sector | Agri-culture | Forestry & logging | Fishing | Mining & quarry-ing | Manufac-turing | Construc-tion | Electr-icity, gas and Water supply | Railways | Trans-port by other means | Storage | Commun-ication | Trade, hotels and restau-rants | Bank-ing & Insur-ance | Real estate, ownership of dwellings and business services | Public admini-stration | Other ser-vices |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Forestry & logging | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fishing | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mining & quarrying | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manufacturing | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Construction | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Electricity, gas and Water supply | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Railways | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Transport by other means | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Communication | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Trade, hotels and restaurants | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Banking & Insurance | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Real estate, ownership of dwellings and business services | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Public administration | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Other services | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

## Table A5: Input-Output 'I-A' Matrix for Goa, 2007-08

| Sector | Agri-culture | Forestry & logging | Fishing | Mining & quarry-ing | Manufac-turing | Construc-tion | Electr-icity, gas and Water supply | Railways | Trans-port by other means | Storage | Commun-ication | Trade, hotels and restau-rants | Bank-ing & Insur-ance | Real estate, ownership of dwellings and business services | Public admini-stration | Other ser-vices |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 0.8455 | 0.0000 | -0.0002 | 0.0000 | -0.0326 | -0.0090 | -0.0021 | 0.0000 | -0.0140 | 0.0000 | 0.0000 | -0.0515 | -0.0001 | 0.0000 | 0.0000 | -0.0023 |
| Forestry & logging | 0.0000 | 0.9986 | 0.0000 | 0.0000 | 0.0000 | -0.0039 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Fishing | 0.0000 | 0.0000 | 0.9841 | 0.0000 | -0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Mining & quarrying | 0.0000 | 0.0000 | 0.0000 | 0.9995 | -0.0100 | -0.0508 | -0.1172 | -0.0015 | 0.0000 | 0.0000 | 0.0000 | -0.0007 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Manufacturing | -0.0633 | -0.0258 | -0.1140 | -0.1105 | 0.5917 | -0.3325 | -0.1280 | -0.2232 | -0.3236 | -0.0768 | -0.1170 | -0.0632 | -0.0347 | -0.0166 | 0.0000 | -0.0840 |
| Construction | -0.0057 | -0.0139 | 0.0000 | -0.0055 | -0.0094 | 0.9657 | -0.0200 | -0.1127 | -0.0080 | -0.0476 | -0.0139 | -0.0061 | -0.0099 | -0.0593 | 0.0000 | -0.0164 |
| Electricity, gas and Water supply | -0.0080 | -0.0007 | 0.0000 | -0.0299 | -0.0255 | -0.0191 | 0.8248 | -0.0758 | -0.0075 | -0.1452 | -0.0170 | -0.0099 | -0.0100 | -0.0031 | 0.0000 | -0.0026 |
| Railways | -0.0024 | -0.0024 | -0.0006 | -0.0084 | -0.0095 | -0.0061 | -0.0224 | 0.9591 | -0.0026 | -0.0044 | -0.0014 | -0.0008 | -0.0037 | -0.0005 | 0.0000 | -0.0008 |
| Transport by other means | -0.0093 | -0.0185 | -0.0098 | -0.0121 | -0.0216 | -0.0314 | -0.0140 | -0.0051 | 0.9751 | -0.0130 | -0.0051 | -0.0246 | -0.0104 | -0.0019 | 0.0000 | -0.0104 |
| Storage | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0002 | 1.0000 | 0.0000 | -0.0052 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Communication | -0.0002 | -0.0011 | 0.0000 | -0.0021 | -0.0025 | -0.0007 | -0.0023 | -0.0004 | -0.0091 | 0.0000 | 0.9876 | -0.0020 | -0.0104 | -0.0025 | 0.0000 | -0.0028 |
| Trade, hotels and restaurants | -0.0520 | -0.0095 | -0.0152 | -0.0166 | -0.0968 | -0.1338 | -0.0855 | -0.0199 | -0.1283 | -0.0191 | -0.0161 | 0.9588 | -0.0300 | -0.0134 | 0.0000 | -0.0363 |
| Banking & Insurance | -0.0050 | -0.0017 | -0.0042 | -0.0151 | -0.0208 | -0.0339 | -0.0315 | -0.0060 | -0.0158 | -0.0257 | -0.0021 | -0.0335 | 0.9297 | -0.0040 | 0.0000 | -0.0143 |
| Real estate, ownership of dwellings and business services | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0007 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0038 | -0.0026 | 0.9516 | 0.0000 | -0.0193 |
| Public administration | -0.0015 | -0.0179 | 0.0000 | -0.0184 | -0.0117 | -0.0002 | -0.0012 | -0.0160 | -0.0367 | -0.0234 | -0.0033 | -0.0025 | -0.0021 | -0.0181 | 1.0000 | -0.0412 |
| Other services | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |

## Table A6: Input-Output 'Leontief Inverse' Matrix for Goa, 2007-08

| Sector | Agri-culture | Forestry & logging | Fishing | Mining & quarry-ing | Manufac-turing | Construc-tion | Electr-icity, gas and Water supply | Railways | Trans-port by other means | Storage | Commun-ication | Trade, hotels and restau-rants | Bank-ing & Insur-ance | Real estate, ownership of dwellings and business services | Public admini-stration | Other ser-vices |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 1.19465 | 0.00469 | 0.01152 | 0.01252 | 0.08261 | 0.05307 | 0.02850 | 0.02957 | 0.05496 | 0.01542 | 0.01254 | 0.07205 | 0.00737 | 0.00604 | 0.00000 | 0.01404 |
| Forestry & logging | 0.00011 | 1.00150 | 0.00002 | 0.00006 | 0.00016 | 0.00414 | 0.00034 | 0.00056 | 0.00013 | 0.00027 | 0.00009 | 0.00030 | 0.00007 | 0.00027 | 0.00000 | 0.00010 |
| Fishing | 0.00011 | 0.00003 | 1.01625 | 0.00009 | 0.00070 | 0.00030 | 0.00018 | 0.00022 | 0.00027 | 0.00010 | 0.00010 | 0.00026 | 0.00004 | 0.00004 | 0.00000 | 0.00008 |
| Mining & quarrying | 0.00447 | 0.00208 | 0.00334 | 1.00883 | 0.02677 | 0.06677 | 0.15083 | 0.02782 | 0.01157 | 0.02761 | 0.00690 | 0.00536 | 0.00385 | 0.00530 | 0.00000 | 0.00427 |
| Manufacturing | 0.16094 | 0.07108 | 0.21709 | 0.22967 | 1.79144 | 0.68735 | 0.37368 | 0.53488 | 0.63122 | 0.24049 | 0.23507 | 0.15737 | 0.09543 | 0.08008 | 0.00000 | 0.17940 |
| Construction | 0.01056 | 0.01610 | 0.00331 | 0.01136 | 0.02415 | 1.04878 | 0.03650 | 0.13215 | 0.01925 | 0.05846 | 0.01872 | 0.01099 | 0.01398 | 0.06624 | 0.00000 | 0.02153 |
| Electricity, gas and Water supply | 0.01901 | 0.00451 | 0.00819 | 0.04646 | 0.06336 | 0.05436 | 1.23710 | 0.11973 | 0.03499 | 0.18897 | 0.03032 | 0.02118 | 0.01823 | 0.00916 | 0.00000 | 0.01119 |
| Railways | 0.00529 | 0.00355 | 0.00320 | 0.01256 | 0.02034 | 0.01615 | 0.03474 | 1.05220 | 0.01068 | 0.01235 | 0.00486 | 0.00356 | 0.00583 | 0.00217 | 0.00000 | 0.00325 |
| Transport by other means | 0.01799 | 0.02187 | 0.01665 | 0.02038 | 0.04826 | 0.05797 | 0.03440 | 0.02720 | 1.04731 | 0.02618 | 0.01313 | 0.03253 | 0.01583 | 0.00719 | 0.00000 | 0.01763 |
| Storage | 0.00046 | 0.00013 | 0.00023 | 0.00027 | 0.00107 | 0.00124 | 0.00087 | 0.00059 | 0.00134 | 1.00040 | 0.00026 | 0.00560 | 0.00026 | 0.00018 | 0.00000 | 0.00034 |
| Communication | 0.00117 | 0.00165 | 0.00095 | 0.00346 | 0.00624 | 0.00454 | 0.00552 | 0.00308 | 0.01227 | 0.00204 | 1.01358 | 0.00343 | 0.01193 | 0.00315 | 0.00000 | 0.00398 |
| Trade, hotels and restaurants | 0.08734 | 0.02319 | 0.04255 | 0.05089 | 0.20343 | 0.23498 | 0.16470 | 0.11177 | 0.21462 | 0.07581 | 0.04912 | 1.07239 | 0.05005 | 0.03466 | 0.00000 | 0.06437 |
| Banking & Insurance | 0.01470 | 0.00543 | 0.01182 | 0.02583 | 0.05241 | 0.06653 | 0.06107 | 0.03284 | 0.04218 | 0.04541 | 0.01145 | 0.04457 | 1.08119 | 0.01055 | 0.00000 | 0.02348 |
| Real estate, ownership of dwellings and business services | 0.00041 | 0.00011 | 0.00021 | 0.00031 | 0.00101 | 0.00117 | 0.00180 | 0.00063 | 0.00100 | 0.00058 | 0.00025 | 0.00444 | 0.00313 | 1.05105 | 0.00000 | 0.02061 |
| Public administration | 0.00478 | 0.01974 | 0.00345 | 0.02250 | 0.02451 | 0.01287 | 0.01116 | 0.02525 | 0.04703 | 0.02842 | 0.00698 | 0.00635 | 0.00435 | 0.02047 | 1.00000 | 0.04476 |
| Other services | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 1.00000 |
| **Output multiplier** | **1.52200** | **1.17567** | **1.33879** | **1.44519** | **2.34644** | **2.31022** | **2.14139** | **2.09848** | **2.12882** | **1.72252** | **1.40338** | **1.44039** | **1.31155** | **1.29654** | **1.00000** | **1.40904** |

## Table A7.1: Economic Value of Direct and Indirect Benefits

| | Total Monetary value (Rs. Crores) | Per Hectare value (RS.) for total forest area of 1424 Sq. km. |
|---|---|---|
| **A. Stock Accounts** | | |
| Total growing stock | 311.74 | 21,892.39 |
| **B. Flow Accounts** | | |
| I. Direct Benefits | | |
| A. Direct Consumptive benefits | | |
| 1.Timber | 48.87 | 3,432.28 |
| 2. Fuel wood | 1.98 | 139.14 |
| 3.Fodder | 21.59 | 1,516.69 |
| B. Direct Non Consumptive Benefits | | |
| 6.Ecotourism | 396.28 | 27,829.31 |
| Total Direct Benefits (A+B) | | |
| II. Indirect Benefits | | |
| 7.Watershed | | |
| (i) Mod. Dense forest | 1,657.81 | 1,37,377.00 (Mod+Open) 1,575,000 |
| (ii) Open forest | 293.91 | |
| (iii) Mangroves | 52.01 | |
| 8. Carbon Sink | 148.60 | 10,435.99 |
| 9.Biodiversity/ | 298.50 | 20,964.74 |
| **Total Economic Value ((I+II))** | 2,926.00* | 205,493.97 |

Total Forest (1,424 Sq. km.), ** and ***excluding watershed Function from Open Forest
Source: Adapted from Verma Madhu Report (2000) (IRADe's source)

## Table A7.2: Economic Value of Forest

| SL.No. | Values of Forests of Goa | Monetary Value (Rs. In crores) |
|---|---|---|
| 1 | Total Economic Value | (+)2,925.93 |
| 2 | Watershed Benefits | (-)2,003.24 |
| 3 | Eco-tourism | (-)396.29 |
| 4 | Carbon sink | (-)148.60 |
| 5 | Fodder (70%) | (-)14.53 |
| 6 | Economic Value of forest of Goa | 363.26 crores |

Source: computed using Appendix Table 7

The Total Economic Value of Goa forest comes out to be Rs. 2,925.93 crores (as explained in Appendix Table A7). The total economic value of Goa forest less the indirect benefits of the eco-tourism value, carbon sink, watershed benefits the value comes to Rs.363.26 crores (Table A7.2) in 2004-05 prices . We used the GDP deflators to get the updated value at 2008-09 prices and estimate the economic value of forests at 2008-09 prices as Rs. 467.62 crores.