Environmental/social performance indicators (ESPIs) and sustainability markers in minerals development: reporting progress towards improved health and human well-being: Phase II

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Project team

Ligia Noronha
Subrahmanya K. Nairy
Sreekanth Venkataraman
Sangeeta Sonak
Mary Abraham
Saltanat M. Kazi
Sudhir Khalwadekar
Shabana M. Kazi

For more information about this report, please contact

Western Regional Centre

T E R I	**Telephone:**	+91 832 425290/421264
Models Residency	**E-mail:**	teriwrc@goatelecom.com
Block 7, G-6		terigoa@goatelecom.com
Near St. Inez Church	**Fax:**	+91 832 425290
Panaji 403 001 / India	**Web Site:**	www.teriin.org/teri-wr

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We thank the focus groups who gave us of their time and patience and helped enrich the project at various points. In particular, we would like to thank Mrs. Suhasini Tendulkar of Pissurlem, who contributed enormously in the work of forming of focus groups. We would also like to thank the Heads of the schools in Bicholim and Codli, for the use of their premises for our meetings. The surveys we undertook to test the QOL tools for the project were time consuming requiring a lot of support from the people of the villages. We are indeed very grateful to them all for their patience with our questionnaires. We thank the Village *Panchayats*, especially the Pissurlem *Panchayat* who also gave us of their time in planning for the project, getting focus groups off the ground, premises for meetings, and responses to the village level indicator information. We are grateful to all the mining companies who have helped us test the indicators. These were also time consuming and their input is much appreciated. In particular we would like to thank Mr. Sridhar of GMOEA and Mr. M Patil of Sesa Goa who helped us at various stages of our work. We thank the Goa Government officials who have helped us too in testing the indicators that were relevant to them. We especially thank Mr. A T D'Souza of the Department of Mines for his inputs, and Mr. S Shanbhouge, Directorate of Planning and Statistics who always helps us with our difficulties.

We are very thankful to the group of young people under the leadership of Mr. Shanshank Thakur who canvassed the questionnaires in the field with us – for their highly spirited hard work that made the survey very enjoyable.

We thank our collaborators MERN and INER for their inputs. Finally, we thank our colleagues P V Sridharan, Divya Datt and S Sreekesh, for their comments and suggestions on our work.

Table of Contents

List of tables

List of figures

List of boxes

Executive Summary

Objectives

The specific objectives of the Indian component of Phase II of this project were the following:

- Joint refinement of the conceptual framework of health and well-being in order to enable the construction of intercultural tools in minerals development.
- Development of a framework of environmental and social performance indicators based on issues identified in Phase I, using a bottom up approach rather than an off the shelf approach and testing of the indicator framework in different clusters in the mining region.
- Development, refinement and testing of the Quality of Life (QOL) tool.
- Developing impact adjusted income accounts for the mineral sector in Goa through valuing the use of minerals and groundwater, the impacts on health and on the environment.

Approach

The approach of the project was transdisciplinary. It involved a research team whose members came from the social, health related, statistical and environmental sciences. The tools and the processes kept evolving based on insights that emerged from the participating disciplines. The research built upon existing databases, based itself on grounded theory, worked with many stakeholders, had a continuous feel for the field data and merged quantitative with qualitative methods to ensure greater robustness of the results. The project has enabled the strengthening of the independent skills of the researchers but also helped them work in a transdisciplinary fashion. This has certainly enhanced the sustainability of this research organization and provided it with the confidence to work using such approaches.

Research methods

- A detailed review was done of quality of life, health, well-being studies. The study also looked into advances in the development of indicators, natural resource accounting, environmental, health and social cost valuations.

- The approach used in the project to assess progress towards improved human well-being is consistent with emerging ecosystem approaches, in which it is explicitly recognised that the well-being of people cannot be separated from the physical, social and economic context in which they are located. This is particularly so in situations wherein there is a development driver that influences these domains in several ways.
- This study adopted a multi-stakeholder perspective–industry, government, and community–to issue identification and validation of issues which served as a basis for the development of tools. This is a central methodological feature of the framework used. At the first level, the issues of concern to stakeholders were identified from the assessment of various domains - economic, social and environmental. These issues were refined further through direct observation in the field, focus group meetings, and semi-structured interviews with key persons in order to triangulate and validate data gathered. This explicit identification of issues with stakeholders is carried out so that these issues can represent the various interests in a mining region, to ensure that all the different versions of reality are captured, and reflected in the proposed tools. At the second level, these identified issues are validated with the three major stakeholders–the state and local government, the local village community, and the mining companies to ensure that the issues are acceptable to all stakeholders, reflect their priorities, and that those issues that are left out are less important than those that are included. The predominant issues from individual and common stakeholder perspectives were organized using a Venn diagram, and a common set of core issues of concern to all three stakeholders arrived at. Tools that have been developed are based on these issues.
- The environmental and social performance indicators are part of Level III of the MERN indicator framework. However the actual indicators were developed using an indicator hierarchy chart using the IUCN methodology (IUCN 1997.) Such a hierarchy displays the domains, issues, sub issues and indicators and enables an understanding of how they relate to each other and to the issues. The initial indicator set developed was tested for validity, relevance and feasibility. The indicators were tested in selected mine sites in selected villages adopting and adapting criteria suggested in the paper by Pannell and Glenn (2000). These were operationalized using a combination of impact indices and R/P ratios which serve to indicate future of activity and

present stress. This method suggested 17 villages. Within these villages, one mine was selected based on the largest current production in the villages. So the sample for indicator testing involved, 17 mines, 8 mine companies and 12 local government authorities. Feedback was obtained for 11 mines from 4 companies and all local government authorities.

- The development of the Quality of life tool involved work on the clarification of the concept of quality of life and what it involves through literature surveys, email discussion with MERN and INER, and interaction with others working in the field of QOL assessments. The process for developing the Quality of life tool was inspired to some extent by that which was adopted for developing the WHOQOL instrument. The domains and sub-domains are defined using an ecosystem approach, in that it involved transdisciplinarity, participatory methods and gender sensitivity. The domains and sub-domains identified in Phase I were refined further; initial testing of the relative importance (weights) of sub-domains and to assess the validity and comprehensiveness of the sub-domains using focus groups in the mining villages was carried out. Questions were set for each sub-domain using notes from the focus group meetings and with reference to the state indicators developed in the indicator framework. A preliminary chapter on the importance rating of domains and sub-domains, commentary on the validity and comprehensiveness of the sub-domain list and the questions to be included in each sub-domain was written and circulated to INER and MERN. The QOL instrument was refined further after issues arising in the other cases were analysed and reviewed. The QOL tool was piloted in selected mining villages in Goa and Mozambique by TERI and MERN respectively; analysis of the results from the pilot study using appropriate statistical methods were obtained; Version III of the QOL tool was fielded in the same selected villages in Goa (17 villages with 5% of population as sample) in three clusters of the mining region and in two villages of a non-mining region. The QOL tool was administered to the head of the household members or to their spouses residing at mining and non-mining villages through systematic random sampling technique. 389 respondents in the mining region were canvassed (cluster I: 116, cluster II: 182, cluster III: 91) and 61 respondents from the non-mining village, of which about 50% were males and 50% females. Each interview took approximately 30 minutes. In this study, subjective satisfaction is measured using a five-point scale. t test for equality of means and one way analysis of variance (ANOVA) methods are used to compare whether any statistical significant differences existed among mining (overall and across clusters) and the non-mining region.

- Impact adjusted income accounts: TERI 1997 study provided the data for the physical assessment of impacts. This was supplemented by a health survey done in 1997 and reported in Phase I of this study. The resource costs were estimated for mineral depletion using change in stock approach (Repetto 1989) and valuing these using the user cost approach (ElŞerafy 1989), for ground water depletion as a by-product of mining using the opportunity costs of supplying tanker water to people affected by water shortages, and for foregone timber of lost forests using imputed values from market data in other states of India[1]; environmental costs were estimated for loss of services from forest lost to mining (Lal 1989). Health costs were estimated for those exposed to air and water pollution and using valuations from other studies done in India (Brandon 1995). Social costs were estimated for those who have their cropland affected either due to loss of soil productivity or to land conversion to agriculture. These valuations are based on yield per hectare and valued at net market prices. This section is an exploratory exercise and the costs need to be revised using more detailed primary data.

Research findings

Development and testing of environmental and social performance indicators

Testing involved ascertaining if:

1 The indicator is meaningful to companies and governments to describe progress.
2 The indicator is realistic and feasible and can be used.
3 The agent and the scale is best suited to provide the information needed.
4 Find out if the data are collectible, do they exist and in what form?

4 large companies responded with regard to 11 mine sites. The small companies and the less progressive did not respond. However, at this stage, the companies responded to all the issues relating to the testing, but not the data as they were not available. It was indicated, however, that the data can be collected

1 There is a ban on timber logging in Goa; hence there is no market for local timber. So loss of timber and non-timber resources connected with forest clearing is valued based on market data from other states in the absence of a direct market.

if required. But the information provided is sufficient to arrive at an indicator sheet that can be used by mining companies in future at the local level. As far as the village level indicators were concerned, we found a great lack of capacity amongst local government representatives in understanding what is involved, what kind of data are needed and how to go about collecting them. There was uncertainty about jurisdictions. However, the testing of the indicators at the state level government level enabled the clarification of the jurisdiction of various departments in relation to issues of concern in the mining region. For the communities, it was felt that indicators of quality of life were the most appropriate.

Quality of Life (QOL) tool

The QOL tool has been developed with the following in mind:

1. Its relevance to mining areas in developing countries.
2. The need to be sensitive to both the charge of conservatism and to that of expert dogmatism in QOL assessments.
3. To be both participatory in its approach and gender sensitive.
4. To have policy relevance.

As we went through our research, we finally worked with three different versions of the QOL tool. The main differences in features across the three versions are given in the table below.

Table 1 Differences across the versions of the QOL tool

Particulars	Version I	Version II	Version III
1 Type	Fully subjective 100 %	Objective: Subjective 50:50	Objective: Subjective 75:25
2 Type of questions	Fully structured closed ended questions	Semi-structured with both closed and open ended questions	Semi-structured with both closed and open ended questions
3 Information	Only subjective, no objective	Covers objective as well as subjective (better coverage of both)	Subjective information is less
4 Time required	45 minutes	1 hour	30 minutes
5 Interviewers view about canvassing	Moderate	Difficult	Easy
6 Data entry and computation	Easy direct	Not so direct	Not so direct
7 Advisable method of collection	Direct filling by respondents	Direct filling by respondents	Interviews/direct filling by respondents

All three versions were tested and found reliable for internal consistency. We believe that all three versions have potential for use depending on the economic and social context of the mining region. Version I will be of importance in a mining region in a developed country, as some basic conditions are already met; Version II would be more appropriate for developing regions where there is a certain degree of political and social emancipation; Version III would be more appropriate for developing regions, where political and social development is more constrained as the level of satisfaction responses are less demanding, but the need to measure objective conditions is very important.

In the testing of Version III, it is observed that while there is a difference in objective conditions between mining and non-mining regions, there is no statistically significant difference in satisfaction levels between mining and non-mining regions except for the environmental domain where the people in the mining region report lower satisfaction levels in all facets of the environmental domain. This difference between levels of satisfaction and objective conditions is especially of importance in the case of women, who report higher satisfaction levels than men but have an overall lower access to resources and other objective conditions, thus supporting the views of Sen and Nussbaum which suggest that QOL assessments should not seek to capture just satisfaction levels as these do not reflect real choices and opportunities in developing countries.

Adjusted income accounts for the mining region

A tool to track sustainability in the mining region has to account for impacts caused by mining activity and then adjust the income obtained from mining to account for such impacts.

Impact adjusted mining income of region (I_m)
= Valued added to GDP by mining in the region (Y_m)
+/- value of mineral resource depletion/enhancement ($V_{md}/_{me}$)
+/- value of environmental degradation/improvement attributed to mining ($V_{ed}/_{ei}$)
+/- value of social impacts attributed to mining (V_{SI})

That is $I_m = Y_m +/- V_{md}/_{me} +/- V_{ed}/_{ei} +/- V_{SI}$

The difference between the environmental and social impact adjusted income for the region and the Y_m of the region is an indicator of the social and environmental changes in the region. The I_m over time can serve as a sustainability marker. If $I_m \geq 0$, then mining contributes to SD.

In this report, the costs of mining in Goa have been estimated. It is important to state at the outset, that the valuation attempted here is based on impacts identified in the TERI 1997 and other secondary data. No new surveys or primary data collection have been done to arrive at more precise estimates of value as the objective here is to demonstrate how the tool can be of use. More detailed studies are required to enable improved estimates of the value of these impacts.

The summary of costs is given in the table below.

Table 2 Summary of costs (Rs. million) from mining impacts

Time periods	Resource costs	Environmental costs	Health costs	Social costs
1996-97	Groundwater depletion: 1.1-1.3		0.1 (water) 4.92-7.90 (air)	Impact on agricultural land:
1996-97 (5%)	Forest timber and non-timber: 85	Forest environmental services: 475		63
1996-97 (5%)	Mineral depletion: 590			

These estimates can be used to operationalize the concept of sustainable development connected with mining operations. The values involved with the environmental costs can be seen as an additional amount that should be contributed by the mining companies to finance environmental rehabilitation using the polluter pays principle. The values under resource, health and social costs can provide the rationale for community development funding. In the case of mineral depletion, this emerges from the fact that once the resource is exhausted there will be no more resource available for the community. Hence a part of the income stream that is generated from the mineral development (the capital component or user cost) needs to be put away to finance community development so that even when the resource is exhausted the community has the necessary skills and resources for alternative development. Unlike environmental costs, this involves an intertemporal interpretation of opportunity costs. This amount should be set aside year after year and invested to create a perpetual stream of income, that would provide the same level of true income both during the life of the resource as well as after the resource has been exhausted. This argument, based on intertemporal equity, also reflected in the views of the people in the focus groups. Mining contributes to sustainable development if $I_m \geq 0$. In the last section of the report, the impacts of mining activities have been valued and netted out from the contribution of the mining sector to the state economy, so as to reflect the true income from this sector. Table 3 below summarises this exercise.

Table 3 Adjusting income for impact (Rs. million)

Year	Value added by 3 clusters to SDP	Value of mineral depletion (user costs)	Value of ground water depletion	Value of forest losses	Health costs	Social costs	Adjusted income or true income
	1	2	3	4	5	6	1 - (2+3+4+5+6)
1996/97	1377	590 (user cost at 5%)	1.2	560	7.91	11.5	206.4

Thus the true income from the study area is not Rs 1377 million, but Rs 206 million.

Research outputs

1 Environmental and social performance indicators for mine companies: company level, mine sites; for government: village and region level.
2 Quality of life indicators for the community.
3 Focus group meeting outputs.
4 A jurisdictional map for the mining region of Goa.
5 Three versions of the QOL tool.
6 A methodology to develop impact adjusted income accounts for mining regions.

This report is in two volumes: The main report and the annexure volume. The main report highlights the process, the methods and results for each tool developed; the annexure volume contains the indicator sheets, the indicator responses, a map depicting data sources and jurisdiction for various mining-related monitoring activities, thick descriptions of the issues raised in focus groups and the three versions of the QOL instrument.

1 Introduction

Background

The Indian study in Phase I of this project aimed at contributing to a conceptual framework for a set of tools meant to track changes in the health and well-being of communities in mining regions. The basis for Phase I was formed by information, insights and data generated by an earlier project on the iron ore mining belt of Goa (TERI 1997), interaction with stakeholders, and literature on issues relating to the project. The framework has the following components: (TERI 1999, chapter 1)

- Human well-being is understood as being made up of constituents (namely, activity, health, freedom and diversity) and these in turn are determined by well-functioning ecosystems, socio-political-cultural and economic systems.
- All domains (such as the biophysical, socio-political-cultural and economic) that affect or are affected by mining and allied activities need to be studied.
- A multi-stakeholder perspective–that of the government, the mining company and the community–is adopted to identify issues of relevance in each domain.
- The use of a causal framework, such as the Pressure-State-Response framework can be adapted to include the exposure to, and impact upon humans for each relevant issue as identified by the stakeholders. This will capture the causes, result, response, and the impact on well-being.

Objectives

The main objectives of TERI's component of Phase II of this collaborative study are:

1 Refinement of the conceptual framework of health and well-being to enable the construction of intercultural tools in minerals development.
2 Development and testing of the indicator framework in Goa, India.
3 Further refinement and testing of the QOL tool.
4 Developing impact accounts for the mineral sector in Goa.

Overview of the method

A detailed review of the quality of life, health and well-being was carried out. The study also looked into advances in the development of indicators, natural resource accounting, environmental, health and social cost valuations.

The project's approach to assess human well-being is consistent with the emerging ecosystem approach, which explicitly recognizes that the well-being of people cannot be separated from the physical, social and economic context in which they are located[1]. This is particularly so in situations wherein a development driver influences these domains.

This study adopted a multi-stakeholder perspective–industry, government, community–to issue identification and validation which served as the basis for tool development. This is a central feature of the methodology in this framework.

At the first level, the issues of concern to stakeholders were identified from an assessment of various domains–economic, social and environmental. These issues were refined further through direct observation in the field, focus group meetings, and semi-structured interviews with key persons in order to triangulate and validate data gathered. This explicit identification of issues with stakeholders in the mining region ensured that different versions of reality are captured, and reflected in the proposed tools.

At the second level, these issues are validated by the state and local government, the local village community, and the mining companies to ensure that the issues are acceptable and reflect the priorities of the stakeholders. The predominant issues from the individual's and stakeholder's perspectives were organized using a Venn diagram to arrive at a set common to the three stakeholders. The tools were developed on the basis of these issues.

The environmental and social performance indicators are part of Level II and III of the MERN indicator framework. However the actual indicators were developed using an indicator hierarchy chart using the IUCN methodology (IUCN 1997). This chart displays the domains, issues, sub-issues and indicators and their relationships. The initial indicator set developed was tested for validity, relevance and feasibility. The indicators were tested in selected mine sites in selected villages adopting and adapting criteria suggested in the paper by Pannell and Glenn (2000, p. 135-149).

[1] See Forget and Lebel 2001 for a discussion of this approach.

The development of the quality of life tool involved clarification of the concept of quality of life and what it involves, through literature surveys, discussion's with MERN and INER, and interactions with others working in the field of QOL assessments. The process for developing the quality of life tool was partly inspired by that used for developing the WHOQOL instrument. The domains and sub-domains are defined using an ecosystem approach, involving transdisciplinarity, participatory methods and gender sensitivity. The domains and sub-domains identified in Phase I were refined further; initial testing of the relative importance (weights) of sub-domains was carried out to assess their validity and comprehensiveness using focus groups in the mining villages. Question were set for each sub-domain using notes from the focus group meetings and with reference to the state indicators developed in the indicator framework. The preliminary chapter dealing with the importance rating of domains and sub-domains, commentary on the validity and comprehensiveness of the sub-domain list and the questions to be included in each sub-domain was written and circulated to INER and MERN. The QOL instrument was refined further after issues arising in the other cases were analyzed and reviewed. A pilot test was used in selected mining villages of Goa, and Mozambique by TERI and MERN respectively; analysis of the data from the pilot study using appropriate statistical methods was obtained. In this study, subjective satisfaction is measured using a five-point scale. The t-test for equality of means and one way analysis of variance (ANOVA) were used to determine whether any statistically significant differences existed between the mining (overall and across clusters) and the non-mining regions.

Impact-adjusted accounts: The TERI study (1997) provided the data for the physical assessment of impacts. This was supplemented by a health survey carried out in 1997 and reported in Phase I of this study. Resource costs were estimated for mineral depletion using the change-in-stock approach (Repetto 1989) and valuing these using the user-cost approach (ElSerafy 1989). For ground water depletion as a by-product of mining resource costs were estimated using the opportunity cost of supplying tanker water to people affected by water shortages and for foregone timber of lost forests using imputed values from market data in other Indian states[2]; environmental costs were estimated for loss of goods and services from forest to mining (Lal 1989). Health costs were estimated for those exposed to air and water pollution and using valuations from other studies in India (Brandon 1995). Social costs were estimated for those

[2] Forest loss does involve loss of timber and non-timber resource in the absence of a direct market.

with affected cropland either due to loss of soil productivity or to land conversion to agriculture. These valuations are based on yield per hectare and valued at net market prices.

The steps followed for the development of tools are given in Figure 1.1.

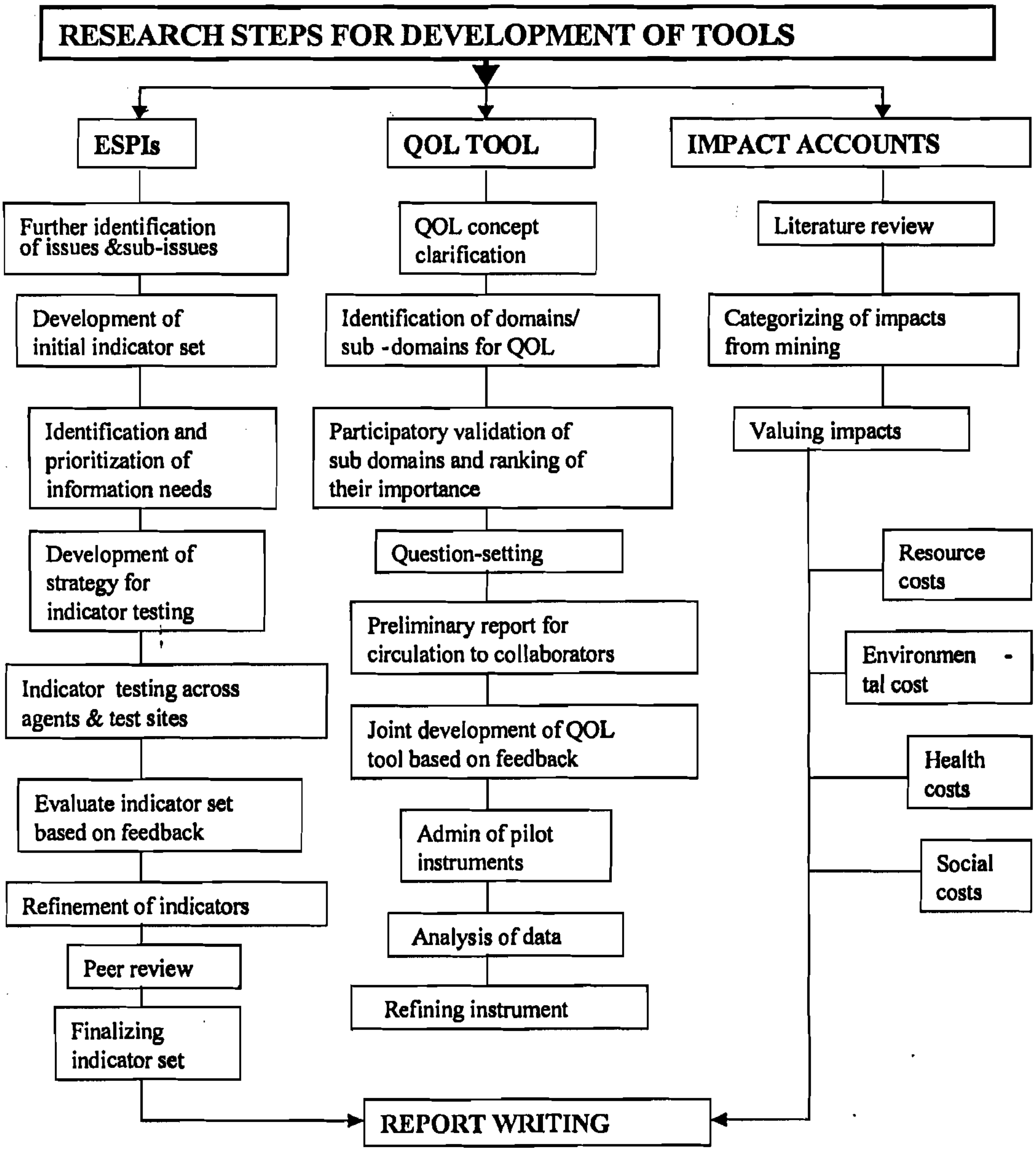


Figure1.1 Research steps

Process

The exercise of defining a framework of performance indicators and sustainability markers for minerals development was designed to have at its centre the needs of at least three sets of user groups:

- The mining company, both corporate management and plant-level staff;
- The government, both in its capacity as regulator and as a development agent; and,
- The public, both local communities and therefore immediate stakeholders, and the wider public.

In order to enable this, the project used a multi-stakeholder process at three levels:

- In identification of issues of concerns
- In addressing issues
- In generating ideas about issues or concepts

Involving the stakeholder in identifying issues

In this project, at the first level, experts identified the issues of concern to stakeholders by assessing the economic, social and environmental domains. These issues were refined further by direct observations in the field, focus group meetings, and semi-structured interviews with key persons in order to triangulate and validate data gathered. This identification of issues with stakeholders was carried to ensure that their issues were representative of the interests in a mining region, and that all different versions of reality are captured, and reflected in the proposed tools[3].

At the second level, the issues were validated with the three major stakeholders to ensure that they were acceptable to all stakeholders and reflected their priorities. The multi-stakeholder perspective is a central methodological feature of this framework.

Involving the stakeholder in addressing issues

This was done both through meetings where all stakeholder groups were invited and also through uni-stakeholder meetings. The multi-stakeholder meetings involved dissemination and feedback from the groups; they also provided a platform for interaction among the groups. The uni-stakeholder meetings took

[3] See MacGillivray and Zadek 1995, p 17 for a discussion on the importance of making transparent the values implied by the adoption of different indicators.

the form of capacity development. The attempt is to change the government's culture, improve practices among mining companies and strengthen the ability of local communities to influence change by increasing their awareness of their rights and options. Meetings with the latter are also being organized to provide them with a platform for interacting. Some meetings were held under other fora, but the objectives of this project were always carried through.

Involving the stakeholder in generating ideas

This was done in focus group meetings which solicited the local people's views on conditions that affected their lives.

The following provides a calendar of activities for the process followed:

- A multi-stakeholder meeting was held on 1 October 1999 to disseminate the findings of Phase I and to explain the nature of the tools that are to be developed in Phase II.
- March to May 2000: The time was spent in understanding the concept of QOL and in developing an initial indicator set.
- A QOL workshop was held on 19 August 2000 in Goa in order to discuss the substantive elements of the concept with a multi-disciplinary group of people. The minutes of this workshop were disseminated to other IDRC collaborators and to Dr J Lebel of the IDRC.
- At a joint meeting between the government and the mining company held on 24 August 2000, the issue of monitoring for health and well-being and the need for setting up a foundation to improve the environmental and social-conditions in the mining belt of Goa were discussed.
- Focus group meetings were organized in our study clusters between November and January 2000-2001; minutes were recorded.

Achievements

In Phase II of this research, the following has been done:

- Development of a framework of environmental and social performance indicators based on issues identified in Phase I, using a bottom-up approach rather than an off-the-shelf approach; also, testing of the indicator framework in different clusters of the mining region.
- Development, refinement and testing of three versions of the quality of life (QOL) tool.
- Development of impact accounts for the mineral sector in Goa by valuing the use of resources–minerals and groundwater, the impact on health of

dust and reduced water quality, impact on the environment from lost forests, on agriculture from siltation of fields.

- Advancement of the use of transdisciplinary approaches. It involved a research team whose members came from the social, health-related, statistical and environmental sciences. The tools and the processes kept evolving based on insights that emerged from the participating disciplines.
- Advancement of the use of a multi-stakeholder research process. The idea of developing tools to track well-being emerged from the concerns identified by the different stakeholder groups in mining regions with regard to their respective roles there.
- The project made a beginning in highlighting gender issues in the mining region in terms of health, impact of environmental degradation, through a gender-based analysis of QOL indicators.

Publications

Noronha L. 2001
Designing tools to track health and well-being in mining regions of India
Natural Resources Forum, **25** (1): 53-65

Noronha L. 2002
A conceptual framework for the development of tools to track health and well-being in a mining region: reporting from an Indian study
In *Managing Healthy Ecosystems*, edited by D Rapport, W Lasley, D Rolston, O Nielsen, C Qualset, A Damania et al.
Boca Raton: Lewis Publishers. Forthcoming.

Dissemination

- Presentations, field visit held on 2 December 2000 with Dr J Lebel of IDRC, Canada and Mr Roger Finan, Regional Director, South Asia.
- TERI participated in the international collaborative research workshop, organized by MERN on 7– 8 December 2000; in the UK.
- Presentation to Mr Derek Sutton, DFID (Advisor, Natural resources), and Ms Janet Riley of IACR, Rothamstead, on 8 January 2001, in Goa.
- Dr Noronha discussed the project at the World Bank Mining Department meeting on 12 January 2001 and left a copy of the presentation with that office.

- Dr Noronha gave a seminar at IDRC Ottawa on 15 January 2001; gave 2 seminars at the University of Quebec in Montreal on 17 and 18 January 2001; and discussed the tools at the MMSD meeting at Chile on 22-23 January 2001. A copy of the presentation was also provided to Duma Nkosi, Member of Parliament, South Africa, and member of the Assurance Group of the MMSD, which he hopes to use in S Africa.
- The project was also presented to Dr Prodipto Ghosh, Senior Environmental Advisor, Asian Development Bank in New Delhi, in April 2001.
- The project was presented at the Ecohealth seminar in July 2001 at the BAIF Centre by Mr Sreekanth V of TERI Goa.
- The project was presented at the Ecohealth Awardees Training Programme at IDRC, Ottawa, August 2001.

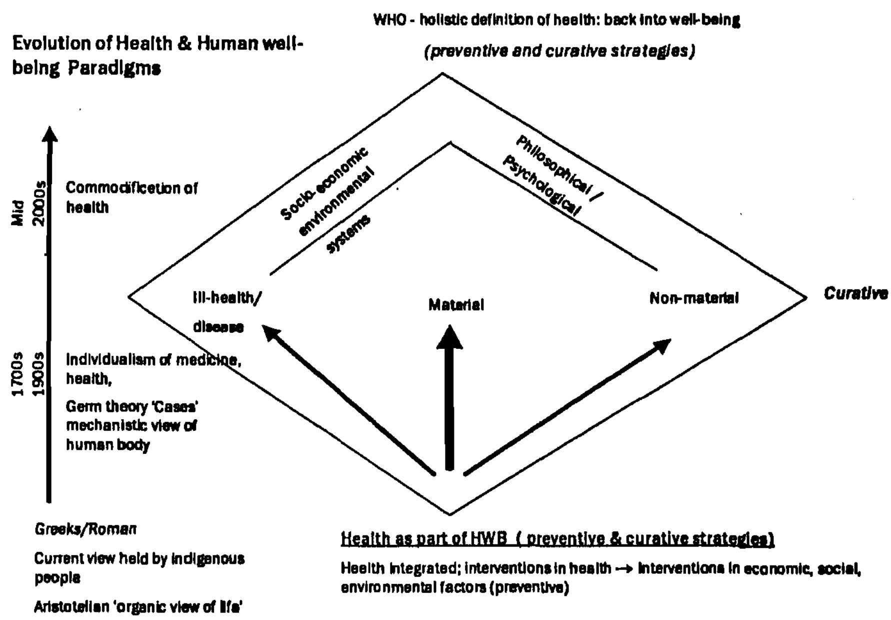
Structure of the report

The report is in two parts: A main report and an annexure volume. The main report is organized into six chapters. Chapter I provides the introduction, objectives and methodology; chapter II summarizes the conceptual framework developed in Phase I which provides the basis for the work in Phase II; chapter III discusses the development and testing of ESPIs; chapter IV provides an account of how the QOL tool was developed and tested and a measure of the QOL in the mining regions; chapter V values impacts of mining activity and adjusts income from mining in the study region and chapter VI is the concluding chapter, summarizing the report and discussing future work. The annexure volume contains the following 6 annexures: indicator sheets, the responses to the indicator testing–company and mine site level, responses to indicator testing–government level, sources of indicator data needs, three versions of the QOL tool and village voices–a report on the focus group meetings.

2 The conceptual framework for the development of tools to track health and well-being in mining regions[1]

Health and well-being

TERI is in broad agreement with the other research teams in that 'health' in its fullest, multicultural connotation equates with well-being or quality of life[2]. This definition is being increasingly accepted by other organizations including the WHO and its acceptance seems to suggest that the understanding of health and human well-being has come full circle (Figure 2.1).



Inspired by Colby 1991, Figure 3

Figure 2.1 Evolution of health and human well-being paradigms

[1] This chapter draws on TERI, Phase I report, chapter I.
[2] Quality of life and well-being are used interchangeably.

Today there is a divide between those who see human well-being as linked to want satisfaction and the deep ecologists who see this view of human well-being as being incompatible with the intrinsic value of non-humans and with future generations. A bridge is obtained in the Aristotelian conception of well-being, discussed in O'Neil and Nussbaum, where the following issues are raised: (See O'Neil 1993, Nussbaum (1990, 2000))

- What does it mean to function as a human being?
- What is good human functioning?
- Is there access to certain objective goods such as friends, choices to develop one's own capacity, shape one's life, opportunities to enjoy beauty?
- Can we speak about goods that are constitutive and goods that are instrumental to flourishing?

If there is a focus on constitutive flourishing, it can be argued that human well-being is compatible with a concern for the good of non-humans and future generations.

Nussbaum (1990, (quoted in Ackerman et al, 1997, p. 274) and 2000, p. 78-80) puts forward a list of functions that can be used to define a good human life. Sen (1987, 1993, 1999, 2000) does not restrict himself to a single correct 'priority' list of functionings. He uses a capability approach: a wide range of desirable, feasible choices; his analysis of human advantage involves many dimensions. Human advantage is a function of both a person's capability set and a chosen combination of functionings. Travers and Richardson (1993) discuss the concept of human well-being as having four components: material well-being, happiness, health and social participation. They point to the argument made by some economists that because material well-being expands options and so contributes to well-being, it can serve as an adequate proxy indicator of individual and national welfare. However they refer to evidence that suggests that while the association between subjective evaluation of happiness and wealth is positive, the relationship is weak. This is because the causes of unhappiness go beyond the realm of material well-being and that in fact there can be trade-offs between material well-being and overall human well-being. They further discuss the relation between material well-being and health, and suggest that the former is important at the national scale in so far as it determines the level of public investment in health services, but that at the individual level, health is related more to the interaction between material and cultural inputs and of the social circumstances that make an egalitarian distribution of these inputs possible.

Some thinkers approach a definition of well-being by composing lists of the elements that go into it (Goodwin 1997). Some decompose well-being into 'subjective well-being and human development' (Lane 1991). Others discuss the concept with reference to two social goals: individual happiness and economic justice. These goals are then decomposed into lists of social values of which each is composed, and the socio-economic outputs required to achieve these values (Wilson 1991).

This conception is similar to that discussed in Dasgupta (1993) where he suggests two ways of assessing human well-being: one by measuring the constituents of well-being (e.g. indices of health), and the other by valuing the commodity determinants of well-being, that is, the goods and services which are inputs in the production of well-being (e.g. real national income). The concept of well-being can be seen more broadly in terms of constituents, i.e., what constitutes our flourishing and the determinants, i.e., what is instrumental to our flourishing (O' Neil 1993). This goes beyond just commodity determinants.

In this framework, we propose to examine the concept of well-being following O'Neil and Dasgupta. That is, in terms of its constituents and determinants. However we will as do the others, continue to make distinctions between 'health' and 'well-being' for political and pragmatic reasons. 'Well-being' and 'quality of life' are used interchangeably within the conceptual framework of the project. The physical and psychological relationships between individuals and ecosystems, and their social and political relationships with the rest of the community as determined by participation and civic engagement are seen as central to well-being. This well-being is dependent on and determined by well-functioning natural and social systems, and is understood here to consist of obtaining the conditions necessary for happiness which do not vary from person to person. The development in the thinking will be evident in the sections below.

The approach used in this study to assess progress towards improved human well-being is consistent with emerging ecosystem approaches, which explicitly recognize that the well-being of people cannot be separated from their physical environment. An equal emphasis is placed on concerns related to the environment, the economy and the community in assessing the significance of an economic activity to human well-being (Forget and Lebel, 2001). The choice of an ecosystem approach reflects a concern about the traditional approach which tends to perceive conditions of the environment or of human well-being using tools based on the biophysical, or economic and social domains independently, but not on all domains together[3]. This results in selective reporting of the conditions and not a more holistic, balanced view. An ecosystem approach dovetails aspects of the traditional approach but broadens out to be more stakeholder-sensitive and holistic. In this approach, data are spatially referenced, organized on the basis of ecologically-defined geographic units as well as administrative units; the boundaries determined by what is to be achieved.

To simplify the task, well-being in mining regions is measured indirectly in terms of its commodity and non-commodity determinants, rather than directly in terms of its constituents. The literature suggests the following as important determinants of human health and well-being:

- Command over goods and services as made possible through increased employment and income. Real disposable income is crucial to a material well-being as it enables the consumption of goods such as food, clothing, medical and legal aid, and general amenities (Dasgupta 1999).
- Availability of goods and services both natural and produced, such as good quality and quantity of air, land and water, as basic determinants of health; or in this case, the production of minerals and the ability to exchange these for other goods and services. This basket of goods and services is important to support and maintain capabilities.
- Participation, a process by which stakeholders voluntarily come together to share, negotiate and control decision-making in development issues, initiatives, decisions and resources which affect them (World Bank 1994). It can improve well-being in the context of mining as it can lead to an improvement in conflict resolution, allow policy, both mining company and government, to be sensitive to the needs and concerns of all stakeholders, and make for increased accountability and transparency (Connor 1997).
- Good governance by which governments and other institutions in civil society create an enabling environment in which rules can be enforced and goals achieved.
- Community and social cohesiveness and systems of reciprocity are possible through efforts at cooperation, such as the building of networks, community relations, etc. Such social capital is particularly valuable where the efficiency of law enforcement is in short supply. Cooperation in terms of playing by

[3] See for example *Reporting frameworks* which report on environmental, economic and socio-economic conditions separately (UNDP, 1990, 1994, 1999; UNEP, 1994; FAO, 1997; United States EPA 1995; Corvalan, Briggs and Kjellstrom 1996).

unwritten rules and social norms then becomes important in progressing towards well-being goals.

The physical and psychological relationships between individual and the ecosystem, and their social and political relationships with the rest of the community in terms of participation and civic engagement are central to well-being. To measure the determinants of well-being in a mining region, there is need to relate the domain level information with the determinants discussed above. This is carried out through the identification of issues of concern to stakeholders.

The multi-stakeholder perspective to issue identification and validation is a central feature of this framework's methodology. It is favoured here for many reasons:

- The tools that are based on the identified issues will address the concerns/needs of all major stakeholders.
- The process is more participatory as the issues are those that have emerged from direct interaction with stakeholders.
- A set of issues common to all stakeholders can be identified from these lists. Tool development can then be based on the smaller set of common issues, which makes the task more manageable.
- Such a core common set, rather than a focus on issues of interest to just one stakeholder, will also be acceptable by a wider audience. Tools based on such issues will therefore have a wider appeal[4].

The selected core issues form the basis of the tools. The objective of tool development is two-fold: (i) to have a measure of current well-being; and (ii) to assess progress towards its improvement. Since tools need to have policy relevance, there is need to draw out what contributes to current well-being, what detracts from it, what can be done to improve it, and what the possibilities are of sustaining well-being. Given these objectives, three sets of tools are suggested:

(a) Environmental and social performance indicators (ESPIs)

Environmental, and social performance indicators based on the issues identified as important from the multi-domain assessment and by the various stakeholders[5].

[4] In fairness however, issues relevant to the community should be given an added weight in the choice of issues that are used for indicator development, in order to concede the point that decisions are made within an asymmetric power matrix where state and company may collude to the disadvantage of the community.

(b) A Quality of Life (QOL) assessment tool

A QOL instrument to assess well-being can be developed with reference to the various domains[6] or it can be a more limited exercise connected to the indicator framework. The measure of QOL will enable the development of an aggregate measure of well-being of people in the mining region, and, if used regularly, enable comparisons the QOL of people over time, the capture of the QOL of communities over different phases of mining activity, for e.g., where mining is new, where it is mature and where it is in the process of closing down.

(c) An impact-adjusted income account of the mining region.

While the tools above seek to measure social well-being, an impact-adjusted income account will assess the long-term viability of the activity. Accounting frameworks explicitly quantify and value economic activity and the use of resources in such activity, either through physical or monetary accounts (Ahmad, Serafy and Lutz 1989; UN 1993). The activity, in this case mining, may have an impact on various domains–natural, economic and social–that make the activity possible and may, over the long run, cause the region to go into a decline. A tool to track sustainability in the mining region is one that accounts for the impact of mining and then adjusts the income obtained from mining to account for such impacts.

In Figure 2.2, the main elements of the framework are summarized.

[5] An indicator is defined as 'a statistic or measure, which facilitates interpretation and judgments about the condition or an element of the world or society in relation to a standard or goal' (US EPA 1995).

[6] It is acknowledged here that a component definition of quality of life is being used (Farquhar 1995).

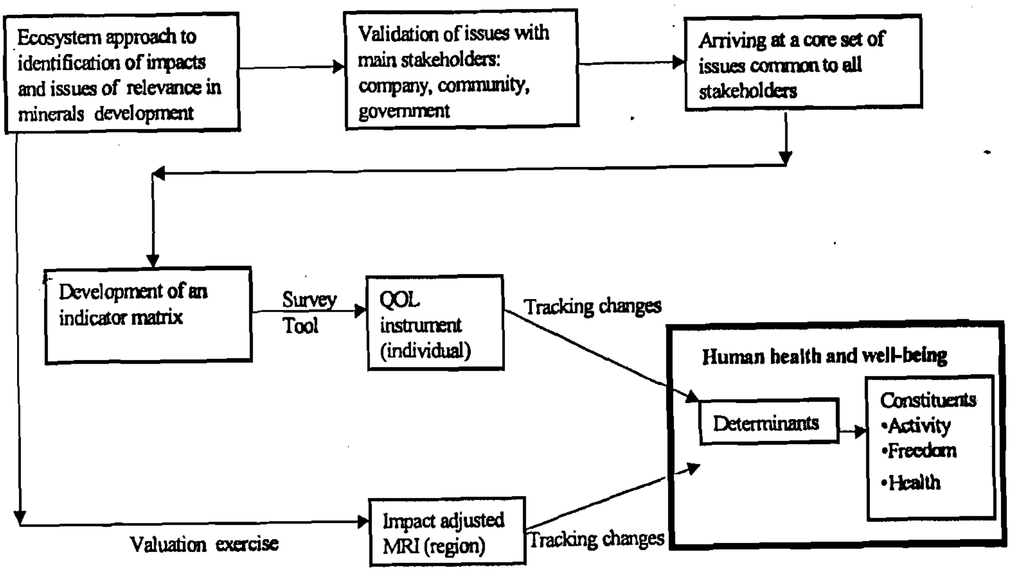


Figure 2.2 Main elements of this conceptual framework

In the chapters that follow, we report on the development and testing of these three sets of tools.

3 The development and testing of environmental and social performance indicators

Introduction

This chapter reports on the development of environmental and social performance indicators in minerals development. It may be recalled that in Phase I, TERI had completed the following: identification of impacts using an ecosystem approach; identification of issues relevant to stakeholders; validation with stakeholders. Predominant issues from the individual and common stakeholder's perspectives were organized using a Venn diagram, and a set of issues common to all three stakeholders arrived at. The following emerged as key issues:

(i) Land: issues of access and compensation; (ii) Environmental quality; (iii) Post-closure economic and environmental issues; (iv) Human and physical investment in the region; (v) Social and community relations; (vi) Effective administrative systems; (vii) Participation; and (viii) Health.

Indicator development in Phase II is based on these issues. The indicators being developed here contribute to Level II and Level III of the MERN indicator framework.

In Phase II, the exercise of indicator development involved the following:

1 Development of an indicator hierarchy and further identification of sub-issues for each core issue identified.
2 Development of and pre-piloting an initial indicator set.
3 Development and implementation of a strategy to test the usefulness and the data requirements for each indicator for selected mining companies and sites and government departments at various levels.
4 Evaluation of the indicator set by the team and by users based on established criteria such as:
    - Relevance: to the user and whether the indicator is able to reflect the purpose/objective.
    - Measurability: if it is possible to estimate the value of the indicator using numerical or non-numerical data.

- Feasibility: effort needed to collect the data and whether the data are readily available or obtainable at a reasonable cost.
- Analytically sound: it is well founded and uses standardized measurement wherever possible to permit comparison.
- Sensitivity: it can show trends over time.

5 Refinement of the indicators based on the feedback from user groups.

Developing an indicator hierarchy and development of sub-issues for each core issue identified

Having identified the main issues for which indicators are to be developed based on stakeholder analysis, an indicator hierarchy (Figure 3.1) was then developed adapting the methodology used by the IUCN (1997). An indicator chart displays the dimensions, issues, sub-issues and indicators and enables us to see how they relate to each other and to the issues (Prescott-Allen 1997).

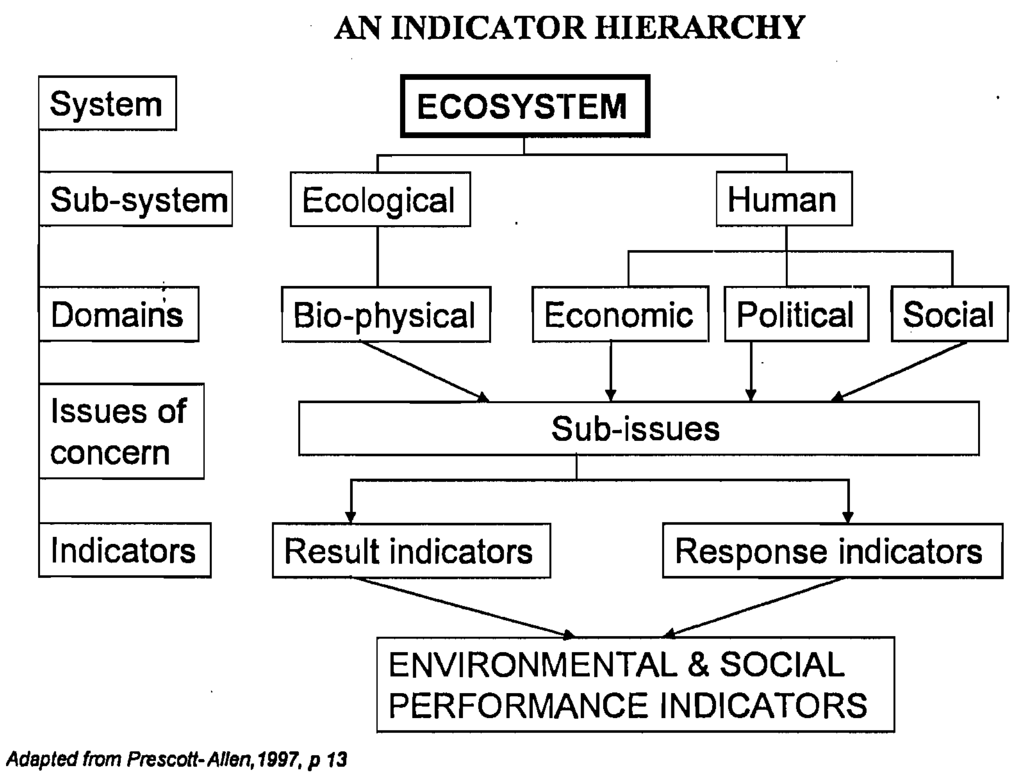


Figure 3.1 Development of an indicator hierarchy

There are two types of indicators (Prescott-Allen 1997)
(i) Performance: those to which values can be defined that are desirable, acceptable or non-acceptable with respect to a particular objective.
(ii) Descriptive: background conditions which set the context and may influence objectives, but will not change themselves.

In this study, indicators are of the performance type which in turn can be either result or response indicators. Response indicators consist of actions taken to achieve an objective. These include responses taken by society to change the conditions of people and/or ecosystems or factors that influence the conditions such as policies, programmes, etc. Result indicators consist of changes in people's lives or ecosystem condition or in factors that influence them. That is, they are state or pressure indicators. State indicators refer to the condition of people/ecosystems based on sub-issues. Pressure indicators are those that either cause or change conditions of people and/or ecosystems. They explain why a particular issue has emerged.

In Phase I, the issues of concern for each of the stakeholder groups were identified, validated and then organized using a Venn diagram. This enabled a listing of issues which were common to the three stakeholders, although the relative importance may differ. The issues common to all three groups were used as a basis for indicator development. The core issues were then grouped into sub-issues of relevance. Chart 3.1 below shows the sub-issues identified for each core issue.

Chart 3.1 Core issues and sub-issues

Core issues identified by multi-stakeholders	Sub-issues
Land: Issues of access	Availability of land for mining needs
Issues of compensation	Compensation payments to farmers
Environmental quality	Air quality, water quality/quantity, land quality, forest degradation
Investment in the mining region:	
- Human	Education, basic amenities, rent sharing with locals, training opportunities, health care facilities
- Physical	Road conditions, water availability, transport
Social and community relations	NGO interference, political interference, media underreporting, cosmetic attention, consultation
Effective administrative system	Rule enforcement, goals achieved, accountability
Participation	Involvement in decision-making, information, availability/accessibility weight in decision-making
Health	Water-related diseases, health care facilities, respiratory diseases
Post-closure issues:	
- Economic and social	Unemployment, income potential, migration rates, alcoholism, depression
- Environmental	Water contamination, dust from tailings, blighted landscape, soil degradation

Source. Phase I report

Development and pre-pilot testing of an initial indicator set

Having identified and validated the main issues and sub-issues for which indicators are to be developed (Chart 3.1) based on stakeholder analysis, an initial indicator set was developed in Phase II. These indicators are measures which facilitate interpretation and judgments about the issue in relation to environmental and social sustainability objectives. The indicator sets were developed within a generic frame at first. For each sub-issue, a measure was identified, the unit of measurement suggested, and its usefulness to a policy objective indicated. Five issues of importance were considered here: (1) the purpose of measurement (2) what is measured (3) the timeliness of the measure (4) the unit of analysis and (5) who does the measuring (Gasteyer and Flora 2000). The attempt was to develop indicators that meet the standards of the scientific community, and also those that encourage public participation (Gasteyer and Flora 2000).

Indicators were identified for each of the sub-issues. A pre-pilot test was carried out with a few companies and the Goa Mineral Ore Exporters Association (GMOEA) to see if the language was clear, and if the indicators captured the policy objective. Some indicators were deleted after they were found not readily comprehensible or irrelevant. Others were added as they were considered important from a multi-stakeholder perspective, but were not captured in the first round of core issue identification. These related especially to worker concerns (important to the company, government and to the community as the workers are part of the local community). Annexure I has details of the indicator sheets.

Indicator testing strategy

To enable a robust testing of indicators with the users, a set of criteria for selecting the scale, feasibility and usefulness of indicators to the key stakeholders was identified. This framework for selection of criteria is adapted from Pannell and Glenn (2000):

1. Criteria for choosing between clusters of villages or the study area.
2. Criteria for choosing among villages within clusters.
3. Criteria for choosing between mine sites.
4. Criteria for choosing between indicators.

1 Criteria for choosing among clusters of villages (TERI 1997)

- Those with active mining and mineral processing.
- Those which lie between working mines and major rivers/streams, and,
- Those having reported a loss of agricultural output due to the impact from mining.

2 Criteria for choosing among villages within clusters

- Presence of a resource management problem, where it is worth adjusting management or policy to deal with the problem (Pannell and Glenn 2000).
- Public recognition of the existence of a resource management problem.
- Presence of baseline information where there is indication of social and economic impacts, positive and negative.
- Potential for future stress in the region from mining using the reserve to production (R/P) ratio.

3 Criteria for choosing between mine sites

- R/P ratio for mines within each cluster.
- Highest current mineral production in the selected villages.

4 Criteria for choosing between indicators

- The indicator would be meaningful to companies for reporting their environmental and social performance and meaningful to governments as a means of describing the state of health and well-being in the village.
- The indicator is realistic, feasible and can be used.
- The agent and the scale is best suited to provide the information.
- The data exist or are collectible.
- The unit of measurement is appropriate.

Three clusters of mining villages that were identified in the TERI 1997 study were used. The choice of villages for indicator testing and validation is based on the magnitude of the management problem. This was determined using an Impact Index that was arrived at from the baseline information collected in 1996/7 and reported in TERI (1997). The potential for future stress was captured by the R/P ratio, which is an indicator of the life of the mine and, therefore, the potential for future impact. Impact indices were classified into four groups based on quartile values i.e. Q_1=4, Q_2=6 and Q_3=9 and Q_4=10+. Among these classes, the impact index range Q_2-Q_3 is moderately stressed and the range higher than Q_3 contain highly stressed villages. R/P ratios are classified into four groups of 0-10, 11-20, 21-30 years and above. So a combination of these two variables will indicate the future of activity as well as the present stress at a glance.

This method suggested a sample of 17 villages of which 11 are highly stressed, but vary in the number of years of mining activity left. This factor was deliberately included to capture the issues associated with closing down. Seven villages are moderately stressed. The selected villages are listed in the chart below.

Chart 3.2 Villages selected for indicator testing

R/P ratio (in years)	0-10	11-20	21-30	Above 30
Impact index				
No stress (upto 4)				
Low stress (5-6)				
Moderate stress (7-9)	Sangod, Bicholim, Lamgao			Maem, Mulgao, Costi,
High stress (10 & above)	Comonem, Cudnem, Santona,	Surla, Velguem, Sigao, Pissurlem, Sonshi	Codli, Sirigao	Pale

Within each village, the mine with the highest production in 1995/96 was selected in order to assess performance and potential for influencing health and human well-being. The mining company operating the selected mine was chosen to test the company level indicators. Thus, testing was carried out across 8 companies and 17 mine sites. Since health and well-being in the villages went beyond the mine site, state indicators that referred to conditions of people/ecosystem in the villages based on sub-issues were tested with the local government. These involved 12 local governments, the *panchayats*, which covered the 17 villages and the various state level departments.

Below are the templates of the indicator testing sheets for the government, and the mining companies.

Template 1 Mining company and mine site

Issues	Indicators	Relevance to good practice, corporate social responsibility/ sustainable development objectives	Unit of measurement	Data (to be filled)	Is the indicator useful? Yes/No	If data do not exist can they be collected?

Template 2 Government level

Issues	Indicators	Relevance to environmental & social objectives (provided)	Unit of measure-ment	Comments: Is the indicator useful? Yes / No	Are you the authority to collect data?	Do you collect the data? Yes/No	If you do collect, in what form ?	If data do not exist, can they be collected?

Evaluation of the indicator set

Results of indicator testing

Company and mine level

Of the 8 companies and 17 mine sites, to which indicator sheets were sent for testing, 4 large companies responded with regard to 11 mine sites. The small companies did not respond. However, at this stage, the companies responded to the issues relating to the testing above, but did not provide the data either because some companies did not have it, or the data was incomplete or the data was, possibly, strategically withheld. All did indicate however, that the data could be collected if required. The information provided is sufficient to arrive at an indicator sheet that can be used by mining companies in the future. However, they are still unclear about how to set up these information systems and develop the databases. The results are given in Table 3.1 and Table 3.2. Annexure II has the indicator sheets which includes the set of indicators with a response rate >50% found to be both useful and feasible and the indicators that were not found useful and feasible. The final sheet will thus include only those indicators found to be both useful, relevant and feasible.

Table 3.1 Mining company level

Domain	Issues	Number of indicators tested	Relevance to objective and usefulness*	Feasibility of use*	Number of indicators found both useful and feasible
Economic	Worked related concerns	26	20	25	20
	Quality of management	2	2	2	2
	Capability to innovate	2	2	2	2
	Market shares	2	2	2	2
	Quality control	1	1	1	1
Total		33	27	32	27
Environmental	EM policy	9	9	9	9
	Closure	6	5	5	5
Total		15	14	14	14
Social	Investment in region	8	8	8	8
	Social and community relations	7	5	6	5
	Land access	1	1	1	1
	Participation	4	4	4	4
Total		20	18	19	18
Political	Effective governance	6	5	5	5
TOTAL		74			50

Note. *Indicators found to have a response rate >50% found to be useful or feasible

Table 3.2 Mining site level

Domain	Issues	Number of indicators tested	Relevance to objective and usefulness*	Feasibility of use*	Number of indicators found both useful and feasible
Economic	Life of mine	1	1	1	1
	Working conditions	3	3	3	3
	Ore quality	4	4	4	4
Total		8	8	8	8
Environmental	Land for dumping	10	8	10	8
	NGO pressure	3	0	1	0
	Expenditure	3	2	3	2
	Water	18	17	16	16
	Air	5	5	5	5
	Biodiversity	7	7	7	7
Total		46	39	42	38
Health	Health	6	4	4	3
Social	Land and compensation	3	2	2	2
TOTAL	65				51

Note. *Indicators found to have a response rate >50% found to be useful or feasible

Government level

The table below provides responses to the testing sheet for indicators at the local government level with regard to baseline conditions, and monitoring in the socio-economic, environmental and health domains. Annexure III has the detailed responses.

Table 3.3 Government level

Domain	Issues	Number of indicators tested	Relevance to objective and usefulness*	Is data collected?	Authority to collect data	Can data be collected in future?
Social and Economic	Land compensation issues, diversification and closure issues	15	15	no	Unclear	15
Environmental	Air, water, land impacts: agriculture and forest, biodiversity	52	52	no	Unclear	52
Health	Facilities, monitoring, expenditure	20	20	no		20
TOTAL		87				87

The research findings suggest that while all indicators were found useful, the village level authorities did not collect data, were not aware that they had the authority to collect data under the 73rd and 74th Amendment of the Indian constitution, but over 80% believed that the data could be collected if needed. The Primary Health Centres when contacted were not able to provide information about the health status of the villagers. As far as the testing exercise of indicators at the local government was concerned, there was a great lack of information, limited capacity to understand what was involved, kind of data needed and how to go about collecting them. They were also unaware of jurisdiction issues, the rules involved and their role in promoting and protecting the health of the local community. These indicators were also tested with other appropriate government authorities that were suggested by the local government representatives. This exercise was useful in that it made possible the drawing up of a map of the data sources for indicators for the mining region. This is included in Annexure IV.

Below is a table that summarizes the results of the indicator testing at all levels. For the mining company level, 74 indicators were tested and 50 were found useful and feasible, i.e., 66%; for the mine site, 65 indicators were tested and 51 were found useful and feasible, i.e., 77%; in case of the indicators at the local village level to be used by local governments, all indicators were found useful and feasible.

Table 3.4 Summary of indicator testing results at three levels

Domain	Mining company level		Mining site level		Village level	
	Number of indicators tested	Number of indicators found useful and feasible	Number of indicators tested	Number of indicators found useful and feasible	Number of indicators tested	Number of indicators found useful and feasible
Economic	33	27	8	8	15	15
Social	20	18	3	2		
Political	6	5				
Environmental	15	14	46	38	52	52
Health	-	-	6	3	20	20

4 Developing a Quality of Life (QOL) assessment tool for mining regions

Introduction

This chapter is in two parts, Section I discusses the development of the tool used to assess the quality of life in the mining regions of Goa and Section II discusses the results of the survey done. The development of a measure for the QOL in mining regions is needed for two reasons; first to provide stakeholders information about the quality of lives of people in mining regions, and, second, as a means of assessing the relative merits of competing interventions to address environmental and social problems in a mining region. The questions that guide this research are: how does mining influence the well-being of people living nearby? How does mining contribute to, or detract from, the provision of necessary conditions for well-being to the people there?

A QOL assessment tool will enable us to:

1 Measure the QOL (or well-being) of people in mining regions.
2 Compare the QOL of people over a time period.
3 Capture the QOL of people in different stages of an economic activity; while it is new, mature, and when closing down.
4 Suggest policies and promote company and government practices that will lead to the improved health, and well-being of people.

The question of how mining influences the well-being of the people living in the region can be examined in three ways:

1 Subjectively, by getting people to evaluate how satisfied they are with the conditions they find in the region.
2 Objectively, by assessing according to some given measure the conditions or resources that people have.
3 By both methods: assess the resources that people have and the conditions they face and then have them evaluate their level of satisfaction.

This decision immediately reflects our concern with the substantive issues underlying the objective/subjective divide in QOL assessments, and the issue of whether we follow a democratic, but conservative approach wherein we ignore the fact that the respondent often adjusts psychologically to the state she faces (Sen 1999) or a more dogmatic, but progressive approach by experts in which people's satisfaction levels are ignored and the expert decides the level of QOL for the people (See Allardt 1993, p. 92) or to attempt both a democratic and a progressive approach.

The QOL tool is being developed with the following in mind:

1 Its relevance to mining areas in developing countries.
2 The need to be sensitive to both the charge of conservatism and to that of expert dogmatism in QOL assessments (Allardt, p. 92).
3 The need to be both participatory and gender-sensitive.
4 To remain relevant to policy as information about resources, conditions and satisfaction levels will be placed in the public domain.

The development of the QOL tool used qualitative and quantitative methods sequentially. The former enabled us to capture more detailed descriptions and new aspects relating to living in mining regions through focus groups and informal workshops; this information and views were fed into the formulation of the QOL survey tool and quantitative methods were used to generalize from the sample to the population. The QOL tool uses both objective and subjective indicators and the analysis of the responses enabled a commentary on the outcomes. A gender analysis was done of the indicator responses. It is hoped that the tool will enable us to suggest interventions and promote improved company and government practices leading to the improved health and well-being of people.

In Section I, we discuss why we chose to develop a new tool rather than use the WHOQOL tool, set out the research steps, state the operational definition of QOL that we chose to work with, discuss the refinement of the domains and the sub-domains, the participatory validation of these sub-domains, their ranking and the development of the QOL tool and its piloting. In Section II, we comment on the findings of the survey carried out using the QOL tool.

Section I

Why not WHOQOL?

Before beginning the detailed discussion of the QOL tool, it is necessary to discuss why this study has had reservations about accepting the World Health Organisation's Quality of Life (WHOQOL) measurement tool as initially suggested by researchers from the University of Bath (see Maclean and Warhurst 1999)[1].

The WHOQOL instrument was designed to measure Quality of Life related to health and health care (Szabo 1996, p. 355)[2]. If this instrument were to be used to measure the well-being of individuals in a mining context, it would imply that health and well-being are both part of the concept of health, thereby ignoring issues relating to well-being. Taking this argument further it can imply that this framework accords importance only to issues relating to health. While biomedical health may be the top most priority in certain countries, the same cannot be said for poor countries, where often long-term health is traded off for short-term employment; individuals may make conscious choices to sacrifice their health for the sake of income to support their families.

The WHOQOL arose from the need to have a measure of the individual's view of the impact of disease and impairment on his/her life across developed and less developed countries (p. 361). Thus, it refers to subjective well-being but related to disease or health impairment. We felt that the use of this health heavy instrument of QOL would imply a prejudgement about minerals development and assume that it will always leads to health impairment.

One of the strongest arguments used by Warhurst and Maclean for using the WHOQOL instrument is that it has been validated in centres across the world. The WHOQOL instrument has been validated for health and health care. It was piloted in centres that were all medical; the population was drawn from those who had diseases; used health services for transient conditions and others in contact with health services (Szabo 1996). It therefore, cannot be assumed that using it to measure well-being in mining regions will have the same validity. The content validity of the WHOQOL instrument in a minerals-

1 This section is drawn from TERI Phase I report, Chapter 6. The discussion below captures some but not all of Crisitina Echevarria's reservation with the WHOQOL instrument. However, it is important to mention that many of her valuable points are not included here.

2 See Warhurst and Maclean, 1999, Para 3.10 '...between sick and well people in relation to health conditions....'

development context is important. In general, what is required to ensure content validity is that concerns/aspects relating to the well-being of the target population are determined through interviews and very open-ended questions and then areas of concern to them are identified. The most frequently cited concerns/aspects are then included into the concept of well-being.

The domains used in the WHOQOL instrument are like a map. In these domains, both constituents and determinants, as used in this study are included. Thus, if health is seen as an output and the commodities and services and the background environment as inputs or determinants or processes though which absence of disease or infirmity is obtained, then Domain V of the WHOQOL instrument includes determinants. A careful perusal reveals that it is incomplete in connection with food security aspects. The identified domains in WHOQOL (see para 4.3 of Maclean and Warhurst 1999) are not all relevant to mining. The domains, as well as their facets, we felt, would need to be changed considerably. If so it made sense for us to draw on the WHOQOL instrument, but develop a separate tool that carried the logic of this joint research further. However, the Mining and Energy Research Network used the WHOQOL instrument in Madagascar with a view to assessing if it captured what we believed was important in a mining context. It emerged that there were several areas or domains of critical importance to communities affected by mining that were ignored or minimized in the WHOQOL. This finding corroborated TERI's research in Goa and INER's research with the indigenous Wayuu peoples in Colombia, both of which also concluded that the WHOQOL was an inadequate instrument to measure the quality of life for primarily rural communities affected by metal and mineral development projects.

Overview of the methodology

The quality of life tool being developed here does, however, have parallels with the WHOQOL assessment tool, but adapts it significantly to mining areas in developing countries. The domains and sub-domains are defined using an ecosystem approach, involving transdisciplinarity, participatory methods and gender sensitivity across disciplines.

The process adopted is similar to that used for developing the WHOQOL instrument. The following research steps were followed:

1 Clarification of the concept of QOL and what it involves, through literature surveys, e-mail discussion across the three collaborating institutions, and interaction with others working in the field of QOL assessment.
2 The domains and sub-domains identified in Phase I were refined further.

3 These were further discussed with focus groups in mining regions to assess the validity and comprehensiveness of the sub-domains. An initial testing of the relative importance (weights) of sub-domains was done.
4 Questions were set for each sub-domain using notes from the focus group meetings and with reference to the state indicators developed in the indicator framework.
5 A preliminary chapter on the importance rating of domains and sub-domains, commentary on the validity and comprehensiveness of the sub-domain list and the questions to be included in each sub-domain was written and circulated among partner institutions.
6 The QOL instrument was refined further after issues arising in the other cases were analysed and reviewed and three versions of the instrument emerged.
7 These versions of the QOL tool were tried out in selected mining villages in India and Mozambique by TERI and MERN, respectively, to test the internal consistency and validity of the instrument.
8 Analysis of the results from the pilot studies using appropriate statistical methods was carried out.
9 The instruments were refined on the basis of feedback from all field studies.

Development and clarification of the concept of QOL

Work on the concept of QOL grew out of the social indicators movement of the 1960s[3]. Researchers used a social-indicator approach to define what QOL meant to them. This was in response to the excessive focus on economic indicators as a measure of development and well-being. The social-indicator approach focussed on external factors, on objective information. All these were researcher-selected/set conditions or domains, which were then pooled to form an index of QOL. However, as Day and Jarkey (1996) pointed out all these reflected the priorities and interests of the individual researcher. The disaffection with this objective approach led to a focus on the individual's subjective reaction to life experiences. Psychological or subjective approaches measured happiness, satisfaction and related attitudes. However, there are a number of problems with this approach recognized in a number of studies (Day and Jarkey 1996, p. 42). They are :

[3] See Day and Jarkey 1996 for a review of the literature.

- Social desirability response bias.
- Idiosyncrasies in reports of feeling states between persons. For example, the meaning of very satisfied could vary between people.
- Variability of response pattern with same individual depending on mood, external conditions.
- Psychological adjustments that people make to conditions that they have to live with and have no control over (Erikson 1993).

In the medical approach QOL assessments have been used to justify or refute different forms of medical treatment, resolve disputes concerning different therapeutic approaches and provide a basis for resource allocation (Day and Jarkey 1996, p. 44). There is no reference to emotional and social factors. Day et al. suggest that a more holistic approach would be one in which the rehabilitative professional seeks to determine from the respondent the criteria that they themselves deem of importance in defining the circumstances of their lives. What needs to be remembered, they say, in QOL assessments is not just the living conditions that affect/influence QOL but the person rearranging living conditions depending on the effect they have on his independence and freedom.

The literature on QOL is replete with definitions. Box 4.1 provides some of the definitions from the medical and nursing literature.

Box 4.1 Some definitions found in the literature

Storrs McCall (1975) **QOL is a measure to which people's "happiness requirements" are met.**

Campbell (1976) described QOL is **" a persons subjective sense of well-being, derived from current experience of the life as a whole"**

Calman (1984) QOL **"is the extent to which hopes and ambitions are matched by experience"**

QOL is an individual's satisfaction or happiness with life in domains he or she considers important" (http://www.atsqol.org/key.html)

Schipper & Clinch (1988) have suggested that **the ambient cultural setting will be a major determinant of the quality of life.**

Bergner (1989) chapters the notion that **QOL is enhanced as the distance between attained and desired goals diminishes.**

Oleson M (1990) **QOL is an individual's satisfaction or happiness with life in domains he/she considers important.**

Carol Estwing Ferrans and Marjorie J Powers (1992) described **'QOL is a person's sense of well-being that stems from satisfaction or dissatisfaction with the areas of life that are important to him/her.**

Meeberg G A (1993)**"a feeling of overall life satisfaction, as determined by the mentally alert individual whose life is being evaluated. Other people also agree that the individual's living conditions... are adequate"**

Farrel B R (1995)**" A personal sense of well-being encompassing physical, psychological, social and spiritual dimensions"**

WHO (1993) defined QOL as **"An individual 's perceptions of their positions in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns.**

It is observed that nursing literature focuses more on the subjective aspects, while that from the social sciences is concerned more with objective assessments. This subjective/objective view of QOL was discussed at an expert workshop held on QOL in August 2000 under this project. One of the points that emerged was that if the QOL concept was perceived to be a subjective one and if used as such, it would be difficult to determine the scope for intervention[4].

Farquhar (1995) while commenting on the lack of consensus on the definition of Quality of Life provides a taxonomy of QOL definitions available in the literature. These are:

- Global, general, definitions which are difficult to operationalize and refer to satisfaction and happiness.
- Component definitions, are those that break QOL down into a series of parts or dimensions or identify those dimensions that are necessary to evaluate QOL. These definitions in turn can be:
  - i) Research-specific, where the focus of research is clear and the task of operationalization has started, and
  - ii) Non research-specific.
- Focussed definitions refer to only one or a small number of components, which can be explicit (definitions such as health-related QOL) or implicit (these are focussed on one or a small number of components but termed QOL).
- Combination definitions are a mix of these.

In this study, we employ a combination definition, with an explicit identification of components or domains relevant to a mining region context. The evaluation of quality of life here is limited to certain dimensions — environmental, socio-economic, political, and health — in order to be able to operationalize the concept. Further, quality of life and well-being are used interchangeably. In order to focus our concepts better, we held a workshop with people from the Goa university, health organizations, other institutes and legal experts. The major points that emerged from this workshop are as follows:

- The subjective-objective divide in QOL assessments. While health scientists approach QOL using an individualistic, subjective path, social scientists approach it through a more objective assessment and bring in the social or community aspect.

[4] P R de Souza, QOL workshop, 19.8.2000, Goa.

- If we want to use QOL assessments as a tool for intervention, then we need to bring in social aspects.
- We need to have an operational definition of QOL that we will use to develop the tool.
- In our study, there must be a control group to ensure that we capture QOL in a non-mining region.
- To achieve the objectives of our study, it may be preferable to adopt a tool that is linked to objective indicators — economic, social and environmental rather than develop a WHOQOL tool since this may create problems.
- We need focus-group meetings to prioritize domains of importance to the target group.

Based on this input, the operational definition that we use for quality of life in our study is 'the satisfaction of a person with the conditions in the domains of life of importance to him/her'. This definition captures the subjective/objective divide as the objective part relates to the conditions in various domains, and subjective is the sense of satisfaction associated with these conditions.

Refinements of the domains and sub-domains initiated in Phase I

This section outlines and defines the domains and sub-domains of quality life that can be applied to people living in mining regions. The domains are the same as those discussed in Phase I — biophysical, social, economic and political — but the sub-domains have been expanded to reflect social, cultural and political concerns. The biophysical domain reflects the idea that the well-being of people cannot be separated from their physical environment. The social and political domains reflect the view that the individual is very much part of the community that s/he belongs to. The physical and psychological relationships between the individual and the ecosystems, and the social and political relationships he/she has with the rest of the community in terms of participation and civic engagement is central to well-being[5]. The economic domain reflects the right to a share in the resources, both economic and natural, and to lead a life comparable to that of others prevailing in the society

[5] By communities here it is meant as in Hempel 1996, p. 237 'interacting population whose limited size and collective sense of responsibility and continuity facilitate the achievement of common goals and lasting relationships'.

(Dasgupta 1999, p. 9). We take the position here that there is a clear link between the prevalence of health or ill-health in any given population, and socio-economic and sociocultural factors. However, health or ill health does not depend merely on social and environmental factors, but also on the individual's physical and psychological capacity to cope effectively with internal and external demands. The health and spiritual domain hopes to capture this view.

It is assumed here, as in Dasgupta (1993), that community or social well-being is an aggregate of individual well-being. As individual well-being rises, so does the well-being of the community to which s/he belongs.

Domain structure

Having discussed the rationale for the domains in the context of our conceptual framework, we discuss the sub-domains or the facets that we need to include. The sub-domains or facets listed below have emerged from the case studies and reflect the issues of concern to people in the mining region that we had obtained earlier.

Box 4.2 The domains and sub-domains or facets

I Biophysical
- Air quality
- Water quality and quantity
- Noise
- Aesthetics
- Land quality and quantity
- Biodiversity

II Social-Cultural-Political
- Social-support networks
- Participation and civic engagement
- Access to and quality of social security systems
- Access to education
- Access to appropriate, adequate and sufficient information
- Availability of amenities
- Conflict resolution mechanisms/organizations
- Political activity
- Legal rights
- Political rights
- Other rights

III Economic
- Access to work and employment conditions
- Income sources: mine and non-mine
- Nutrition and food security
- Traditional livelihood opportunities
- Infrastructural services
- Availability of fuel sources
- Opportunities for acquiring new skills

IV Health/Spiritual
- Chronic diseases/illness in family, health care facilities: Access and quality
- Pain and discomfort
- Health care facilities
- Dependence on medical aid
- Spirituality/religion and personal beliefs
- Interculturality of medical attention systems

Assessing the validity and comprehensiveness of the sub-domains using focus groups

In order to assess the validity and the comprehensiveness of the domains and sub domains, we relied on focus groups. A focus group is a group brought together to generate ideas about an issue or a concept. They differ from formal surveys in the method of collecting information. We adopted a focus group approach in order to avoid a researcher-driven approach to study QOL. In this way, we hoped to be able to identify aspects of importance to people and delete irrelevant aspects.

However, to ensure that focus groups (FG) were in a position to represent typical views of the mining region, the TERI project adopted 3 FG in the three clusters of our study. Each focus group had 10-12 persons each, from a variety of backgrounds. Focus group formations built on our existing relationships in the mining belt.

Box 4.3 Focus Group details

Cluster I
Number: **13**
Male/female: **9/4**
Age: **20-56**
Schooling: **Graduates**
Occupation: **Student, teaching, labourers, miners, social workers, government, bank employees**

Cluster II
Number: **13**
Male/female: **6/7**
Age: **25-55**
Schooling: **3rd- graduate**
Occupation: **mining, social work, farmer, housewives, carpenter**

Cluster III
Number: **15**
Male/female: **11/4**
Age: **25-49**
Schooling: **7th-post graduate**
Occupation: **teachers, labourer, mining, social work, government, bank, farmer, transport contractor, school principals**

The purpose of these focus groups was to get comments and views on conditions that can make life more positive or negative. Thick descriptions are provided in Annexure V.

Analyzing focus-group data

The groups were also asked to rate the importance they would place on the sub-domains on a qualitative scale. They were asked to suggest any facets that had been left out or to mention those they found irrelevant. The transcripts of the discussions were used to frame questions for the pilot tool. The hypothesis that guided this phase of our work is that the importance rating for facets will vary across clusters reflecting the age and stage of mining and the relative socio-economic development in the clusters.

Importance rating across mine clusters

The results of the importance rating of each facet are given in the tables below.

Table 4.1 Biophysical

	Cluster I	Cluster II	Cluster III
Domain-I	Mean score	Mean score	Mean score
Water quality	4.7	5	4.9
Air quality	4.5	4.9	4.8
Water quantity	4.4	4.5	4.6
Land quality	4.4	4.7	4.3
Land quantity	4	4	4.1
Noise	3.8	3.3	1.9
Biodiversity	3.8	4.2	4
Aesthetics	3.8	4.2	4.3

NB: 1-least; 5-highest

From ANOVA of each facet, it is observed that there was significant difference (at the 5% level) between scores of free from noise among the 3 clusters.

Table 4.2 Economic

	Cluster I	Cluster II	Cluster III
Domain-II	Mean score	Mean score	Mean score
Access to work	4.5	4.6	4.8
Food security	4.5	5	4
Income sources	4.4	4.8	4.7
Nutrition levels	4.3	4.9	4.6
Employment conditions	4.2	4.2	4.2
Infrastructure services	4	4.5	3.9
Availability of fuel	3.9	4.2	4.1
Traditional livelihood opportunities	3.8	4.7	3.6
Opportunity to learn new skills	3.8	4.2	4.4

NB: 1-least; 5-highest

From ANOVA of each facet, it is observed that there was significant difference (at the 5% level) between scores of food security and traditional living opportunities among the 3 clusters.

Table 4. 3 Social (Socio-cultural-political)

	Cluster I	Cluster II	Cluster III
Domain-III	Mean score	Mean score	Mean score
Access to education	4.8	4.9	4.4
Access to information	4.7	4.7	4.1
Legal rights	4.5	4.5	3.9
Participation in decision	4.2	4.6	3.9
Social support network	4.1	4.5	4.1
Engagement in civic life	4.1	4.2	4.1
Access to social security system	4.1	4.3	3.6
Quality of social security system	4.1	4.3	3.6
Availability of amenities	4.1	4.3	3.8
Mechanisms to resolve conflict	4	4.4	3.2
Political rights	3.4	4.7	3.4
Political activity	3.3	4.3	2.9

NB: 1-least; 5-highest

From ANOVA of each facet, it is observed that there is significant difference (at the 5% level) between the mean scores of participation in decisions, access to education, mechanisms to resolve conflict, political activity and political rights among the 3 clusters.

Table 4.4 Health

	Cluster I	Cluster II	Cluster III
Domain-IV	Mean score	Mean score	Mean score
Health care facilities	4.8	5	4.8
Chronic illness in family	4	4.9	4
Pain and discomfort	4	4.7	3.4
Different medical systems	3.8	4.8	3.7
Personal beliefs	3.8	4.8	4
Spirituality/Religion	3.5	4.5	4.2

NB: 1-least; 5-highest

From ANOVA of each facet, it is observed that there is a significant difference (at the 5% level) between the scores of the facets chronic illness in family and spirituality/religion among the 3 clusters.

Preliminary results indicate that importance rating does not vary across clusters for all the domains except for a few facets. This suggests that all facets are of importance irrespective of socio-economic conditions.

Reliability tests

In order to check the internal consistency[6] of the QOL domains, an internal consistency reliability assessment of the facets included in the domains using focus group data was done. Internal consistency is an indicator of how well the different items measure the same issue. "Reliability is concerned with how consistently and accurately the measurement technique measures the concept of interest" (Burns and Grove 1999, p. 291). One of the methods for testing the reliability of the tool is the homogeneity procedure that examines the extent to which all the items in the instrument measure the same construct, i.e. it measures the internal consistency of the items in the tool. One of the statistical procedures used for this process is the Cronbach alpha coefficient (Cronbach 1951) which was calculated for the focus group data[7]. A low coefficient alpha (<0.50) indicates that the items do not come from the same conceptual domain (Table 4.5).

[6] Internal consistency reliability is a commonly used psychometric measure in assessing surveying instruments and scales.

[7] This is expressed thus: $\alpha = N/(N-1)[1-\Sigma\sigma^2(Yi)/\sigma^2_x$; where N is equal to the number of items; $-\Sigma\sigma^2(Yi)$ is equal to the sum of item variances; and σ^2_x is equal to the variance of total composite.

Table 4.5 Internal consistency test using Cronbach alpha coefficients

Village	Domain I	Domain II	Domain III
	α	α	α
Cluster I	0.774363	0.905328	0.802795
Cluster II	0.590847	0.847277	0.97437
Cluster III	0.241509	0.873048	0.79023
All together	0.90746476	0.984238	0.934991

Focus group research using both qualitative and quantitative data suggested the following:

- The need to have a separate political domain, instead of clubbing it with the social domain.
- More items to be included in our domain facets based on the discussions that emerged.
- The internal consistency test of the importance scale based on Cronbach's alpha also suggested reworking Domain I as II and III emerged internally consistent.
- The need to do the importance scaling again as we were unable to arrive at a definitive weight for the facets within each domain and across the domains.
- The need for greater attention to gender in developing the QOL tool.

Developing the pilot tool

This stage involved the following:

1. Identifying further issues for inclusion in the questionnaire from focus group meetings and discussions.
2. Preparing a first approximation of the tool to share with collaborators.
3. Inclusion of items from the INER tool, and
4. Reworking the tool further.

As we went through our research, we finally worked with three different versions of the QOL tool. All three versions are given in Annexure VI.

VERSION I	VERSION II	VERSION III
Fully Subjective	Objective 50% Subjective 50%	Objective 75% Subjective 25%

Version I

The tool has two parts, following the work of Ferrans and Powers (1992) i.e. Part A. Importance Scale, and Part B. Satisfaction Scale.

Version I had 120 importance questions and 127 satisfaction questions in 6 domains. Both parts have same items, with part A measuring satisfaction of the item and part B measuring its importance. The product of these importance and satisfaction ratings gives the Quality of Life index, under each of the questions, domains and alltogether.

The QOL tool is designed to differentiate by the following:

- Gender
- Age
- Literacy level
- Mining clusters
- Migrant status
- Income

Pre-pilot testing of the tool was carried out informally with people from different socio-economic backgrounds for general feedback on the use of scales, language, clarity of questions used and sequencing of questions. This was followed by:
An intensive internal whole day meeting to discuss the feedback. Based on this the questionnaire was changed again to use pictorial scales; (small dots and big dots); inclusion of items in different domains; the anchor points: very unimportant – very important; very dissatisfied – very satisfied, with the middle point as neither important nor unimportant and neither satisfied nor dissatisfied.

About the scaling: We tried both 3 and 5 scale points on people with no education (i.e. illiterate) and with education. We found we could not work with the semantic differentials (very unimportant - unimportant - neither important nor unimportant - important - very important) with the former, but we could work with symbols: small dots to large dots.

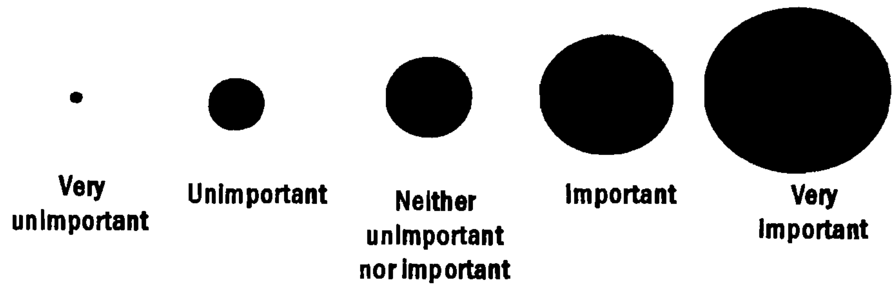


Figure 4.1 Scale of importance

This approach worked very well, so we decided to go with the scale of 5 as we felt we would lose some information if we did not have the 5 levels.

Objectives of the pilot testing of the QOL in Goa:

1 Testing the acceptability of the question to the respondent (i.e., whether there was a consistent non-response to a question).
2 Testing the applicability of the questions to the respondents (i.e., whether people consistently say that a question is non-applicable).
3 Rating the importance of the facets by using the importance scale; ascertaining the relative weights of the domains across our clusters and across the mining and the non-mining group.
4 Testing reliability (internal) using Cronbach's alpha method.
5 Difference in domain importance and satisfaction level (the QOL index) between the different mining regions and the control (non-mining region) and by gender. The other variables were not analyzed in this pilot test.
6 Local specific feedback and additional items if needed for the tool.
7 Feedback from interviewers about the facets.

Pilot test of version I of the QOL tool: expectations and results

The QOL tool was tested for (i) reliability (ii) relative importance of questions (iii) differences in satisfaction in mining and non-mining and across gender (iv) clarity of concepts to respondents. This was done in two villages; a mining village in Satari and a non-mining village in Quepem. Both villages are in similar geographical and environmental regions, but in one mining is very active and in the other, there is no mining. The QOL importance and satisfaction scales were administered to the head of the household or his/her spouse living in the non-mining village and mining village by the systematic random sampling technique (spatial sampling). We had 25 respondents in each village of which 50% were males and 50% females. Each interview took approximately 45 minutes.

(i) Reliability

The coefficient of internal consistency was computed by Cronbach's alpha method (Table 4.6).

Table 4.6 Importance scale in a non-mining village

Domains	Items	Cronbach Alpha
Economic	24	0.77
Cultural	27	0.84
Political	23	0.89
Biophysical	17	0.83
Biomedical	28	0.9
Spiritual	7	0.76
Total	126	0.96

The QOL importance scale in the table shows that the reliability of all the QOL domains was high. The reliability for the total QOL importance scale was 0.96.

Table 4.7 Importance scaling in a mining village

Domains	Items	Alpha
Economic	24	0.84
Cultural	27	0.89
Political	23	0.92
Biophysical	17	0.92
Biomedical	28	0.94
Spiritual	7	0.71
Total	127	0.97

The QOL importance scale in the table shows that the coefficient of internal consistency of all the QOL domains was high. The reliability for the total QOL importance scale was 0.97 (Table 4.7).

QOL satisfaction scale

The QOL satisfaction scale shows that the internal reliability of all the QOL domains was high in both villages. The reliability for the total QOL importance scale was 0.98 and 0.99 for the non-mining and mining village respectively (Tables 4.8 and 4.9).

Table 4.8 Satisfaction scaling in the non-mining village

Domains	Items	Alpha
Economic	30	0.94
Cultural	27	0.91
Political	23	0.93
Biophysical	17	0.81
Biomedical	29	0.93
Spiritual	8	0.74
Total	134	0.98

Table 4.9 Satisfaction scaling in the mining village

Domains	Items	Alpha
Economic	30	0.93
Cultural	27	0.91
Political	23	0.98
Biophysical	17	0.97
Biomedical	29	0.98
Spiritual	8	0.84
Total	134	0.99

The conclusion arrived at from this analysis is that the reliability of the tool is good with respect to internal consistency in each of the individual domains and alltogether, both on the scale of importance and satisfaction.

(ii) Relative importance rating

The importance rating of questions was found to be high both in mining and non-mining regions, which suggests that the facets that have been used to capture aspects of QOL are equally important. We were unable to delete any items based on this as all were rated 4 (important) and above. We, therefore decided not to have importance items in future versions to save respondent fatigue.

(iii) Comparison between mining and non-mining villages

QOL importance rating and satisfaction levels were compared in this section using the t-test for equality of means. Results were significant at the 5% level of significance presented in the last column of the tables (Tables 4.10 and 4.11).

Table 4.10 Importance rating in mining and non-mining village

	Non-mining village		Mining village						
Domains	Mean	SD	Mean	SD	n_1	n_2	t	t-table value	
Economic	4.41	0.31	4.27	0.33	25	27	1.58	1.174	
Social	4.5	0.29	4.4	0.34	25	27	1.12	1.174	
Political	4.08	0.46	4.21	0.48	25	27	0.97	1.174	
Biophysical	4.58	0.34	4.22	0.38	25	27	3.51	1.174	P<0.05
Biomedical	4.54	0.37	4.49	0.36	25	27	0.53	1.174	
Spiritual	4.5	0.49	4.49	0.34	25	27	0.15	1.174	
Total	4.46	0.31	4.38	0.32	25	27	0.96	1.174	

It is only in the biophysical domain, that the difference in the importance rating is statistically significant; in all other domains they are not. People in the mining region rate the importance of the biophysical lower than those in non-mining villages.

Table 4.11 Satisfaction ratings in the mining and non-mining village

	Non-mining village		Mining village						
Domains	Mean	SD	Mean	SD	n_1	n_2	t	t-table valua	
Economic	3.59	0.71	3.28	0.56	25	25	1.72	1.174	
Social	3.77	0.56	3.7	0.54	25	25	0.48	1.174	
Political	3.41	0.74	3.36	0.61	25	25	0.26	1.174	
Biophysical	4.24	0.45	3.27	0.56	25	25	6.71	1.174	P<0.05
Biomedical	3.65	0.6	3.26	0.4	25	25	2.73	1.174	P<0.05
Spiritual	4.43	0.4	4.03	0.5	25	25	3.13	1.174	P<0.05
Total	3.74	0.54	3.42	0.42	25	25	2.39	1.174	P<0.05

However, on the satisfaction scale, we find that there are number of differences between the mining and non-mining villages. In general, satisfaction levels were lower with conditions in all domains in mining villages, but especially so in the biophysical, biomedical and spiritual domains.

(iv) Gender-wise comparison across mining and non-mining villages

There is no significant difference in the importance rating between males and females in either of the villages as can be seen from Tables 4.12 and 4.13 below.

Table 4.12 Gender-wise comparison of importance across non-mining village

	Male		Female					
Domains	Mean	SD	Mean	SD	n_1	n_2	t	t-table value
Economic	4.41	0.27	4.42	0.38	15	10	0.05	1.174
Social	4.45	0.29	4.58	0.3	15	10	1.02	1.174
Political	4.09	0.38	4.06	0.57	15	10	0.16	1.174
Biophysical	4.53	0.37	4.64	0.32	15	10	0.77	1.174
Biomedical	4.56	0.33	4.52	0.46	15	10	0.22	1.174
Spiritual and religious	4.49	0.43	4.53	0.58	15	10	0.21	1.174
Total	4.45	0.27	4.48	0.38	15	10	0.24	1.174

Table 4.13 Gender-wise comparison of importance across mining village

	Male		Female					
Domains	Mean	SD	Mean	SD	n_1	n_2	t	t-table value
Economic	4.27	0.29	4.29	0.32	14	11	0.18	1.174
Social	4.34	0.21	4.52	0.41	14	11	1.44	1.174
Political	4.29	0.24	4.12	0.67	14	11	0.89	1.174
Biophysical	4.2	0.29	4.3	0.48	14	11	0.66	1.174
Biomedical	4.44	0.31	4.58	0.42	14	11	0.96	1.174
Spiritual and religious	4.41	0.31	4.55	0.39	14	11	1.02	1.174
Total	4.36	0.22	4.42	0.41	14	11	0.51	1.174

However in the satisfaction scaling, there are significant differences between males and females responses in all domains, except spiritual in the non-mining village, with females reporting lower satisfaction levels (Table 4.14).

Table 4.14 Gender-wise comparison of satisfaction across non-mining village

	Male		Female						
Domains	Mean	SD	Mean	SD	n_1	n_2	t	t-table value	
Economic	3.91	0.55	3.1	0.65	15	10	3.36	1.174	P<0.05
Social	3.99	0.48	3.45	0.55	15	10	2.63	1.174	P<0.05
Political	3.76	0.65	2.88	0.53	15	10	3.58	1.174	P<0.05
Biophysical	4.45	0.3	3.91	0.47	15	10	3.52	1.174	P<0.05
Biomedical	3.92	0.49	3.26	0.54	15	10	3.2	1.174	P<0.05
Spiritual and religious	4.47	0.36	4.38	0.47	15	10	0.55	1.174	
Total	4	0.42	3.34	0.45	15	10	3.74	1.174	P<0.05

In the mining village too, females report lower satisfaction levels in all domains, but most significantly in the social and biomedical (Table 4.15).

Table 4.15 Gender-wise comparison of satisfaction across a mining village

	Male		Female						
Domains	Mean	SD	Mean	SD	n_1	n_2	t	t-table value	
Economic	3.44	0.43	3.07	0.65	14	11	1.72	1.174	
Social	3.88	0.37	3.46	0.65	14	11	2.04	1.174	P<0.05
Political	3.53	0.46	3.15	0.73	14	11	1.59	1.174	
Biophysical	3.36	0.51	3.15	0.62	14	11	0.96	1.174	
Biomedical	3.4	0.33	3.08	0.43	14	11	2.16	1.174	P<0.05
Spiritual and religious	4.06	0.45	3.99	0.57	14	11	0.37	1.174	
Total	3.56	0.27	3.23	0.5	14	11	2.14	1.174	P<0.05

Overall quality of life: Overall quality of life index is computed by multiplying satisfaction and importance scores. It is converted into a 5-point scale. The results are given below.

Table 4.16 Overall quality of life index

	Mining		Non-mining		
Domains	Mean	SE	Mean	SE	Significance
Economic	2.86	.11	3.22	.14	P<.05
Social	3.29	.10	3.43	.12	
Political	2.93	.14	2.95	.16	
Biophysical	2.93	.11	3.90	.11	P<.05
Biomedical	2.95	.06	3.35	.08	P<.05
Spiritual and religious	3.68	.13	4.10	.14	P<.05
Total	2.94	.07	3.31	.11	P<.05

Concluding remarks

While the reliability tests of the importance of items to be included in the QOL tool suggest that these items are indeed of importance to the people, irrespective of whether they are in the mining or non-mining villages, the satisfaction levels are different between the two villages. The interviewers, however, felt that people were saying that they were satisfied even when it was apparent (to the interviewers) that the conditions they observed were bad and the respondents had little command over resources. Given this observation and the contention in the QOL literature that satisfaction levels reflect people's adaptation and resignation to their life conditions, we decided to use both objective and subjective measures of well-being. The revised tool reflects this change.

Pilot test of version II of the QOL tool: expectations and results

As discussed above, the pilot test as also the literature suggested the need to include both objective and subjective measures of quality of life or well-being. The reasons for this are:

- That the separate investigation of each domain in terms of objective and subjective indicators would be a useful exercise as it could provide important insights into the QOL construct (Cummins 2000, p. 56).
- The satisfaction levels reflect people's adaptation and resignation to their life conditions (Nussbaum & Sen 1993, Erikson1993, p. 77), and hence need for a greater focus on objective measures.
- That for any intervention, there is need for information on both objective conditions as well as satisfaction levels.

In order to respond to these views a new version was developed. This involved a 12-field table as given below.

Table 4.17 Use of objective and subjective measures to assess QOL

Domains	Objective measures	Subjective measures
Economic	Level of resources and conditions	Level of satisfaction with resources and conditions
Social	Level of resources and conditions	Level of satisfaction with resources and conditions
Political	Level of resources and conditions	Level of satisfaction with resources and conditions
Biophysical	Level of resources and conditions	Level of satisfaction with resources and conditions
Biomedical	Level of resources and conditions	Level of satisfaction with resources and conditions
Spiritual	Level of resources and conditions	Level of satisfaction with resources and conditions

The QOL tool was tested for reliability and practicability in Mozambique by MERN[8].

A sample of 26 respondents was interviewed in a mining village with equal representation from the male and female population. Results reveal that overall internal consistency of the tool is good. About 35% of the respondents are satisfied with their life, while 65% are indifferent about satisfaction or are not satisfied. Maximum dissatisfaction is observed in the economic domain; maximum satisfaction is observed with the spiritual and biophysical domains; satisfaction in the social, health and political domains are in the middle range. Satisfaction with overall QOL is similar among the male and female population. In the economic domain, women (42.3%) are more dissatisfied

[8] The survey results of Mozambique are provided in the integrated report.

than men (34.6%), while in the health domain, women (26.9%) are more satisfied than men (15.4%).

The interviewers felt that the format was easy to follow and liked the use of the pictorial scale of satisfaction rating. People stated that no areas important to their quality of life were left unmentioned. Some changes were suggested based on semantics. One of the points raised however, was the length of the tool. It was then decided to rework the tool to reduce respondent fatigue.

Pilot test of version III of the QOL tool

A new version was developed which included most of the objective questions, but limited the satisfaction questions to the level of a sub-domain rather than for each issue within the sub-domain. This tool was then tested in Goa, on 400 people in mining and non-mining villages. Cronbach's alpha reliability test was done for the subjective indicators of QOL version III and its results are given below.

Reliability test results

The coefficient of internal consistency was computed using Cronbach's alpha method. The QOL satisfaction scale shows that the internal reliability of all the QOL domains was high in both regions. The spiritual domain was not covered, as there are only three items.

Table 4.18 Reliability test results

Domains	Mining	Non-mining	Number of questions
	Alpha	Alpha	
Economic	0.74	0.76	9
Social	0.58	0.82	9
Political	0.52	0.61	5
Biomedical	0.55	0.93	5
Biophysical	0.69	0.87	5
Spiritual			3
All together	0.83	0.86	36

Version III was canvassed in the same 17 mining villages selected for the indicator testing in order to have a common baseline for all sets of indicators. To compare conditions in non-mining villages, 2 villages in the same geographical region were selected, where there is no mining activity taking place, and where no main workers in the villages were reported to be involved in mining activities in the Census reports. The sample consisted of 5 % of the households in each village. The QOL tool was administered to the head of the household or to his/her spouse living in the mining and non-mining villages through a systematic random sampling technique. Each interview took approximately 30 minutes. A description of the sample is given below.

Table 4.19 Sample description

% of respondents	Mining			Non-mining		
	Number of respondents: 389 Cluster I: 116 Cluster II: 182 Cluster III: 91			Number of respondents: 61		
Gender %	Male	Female		Male	Female	
	52	48		46	54	
Migrants %	Local residents	Migrants		Local residents	Migrants	
	72	28		72	28	
Income %	< Rs 2000	Rs 2000 - 5000	> Rs 5000	< Rs 2000	Rs 2000 - 5000	> Rs 5000
	25	51	24	25	51	24
Years of stay %	<=10 yrs	11 - 20 yrs	> 20 yrs	<=10 yrs	11 - 20 yrs	> 20 yrs
	12	11	77	3	18	79
Age group %	< 40 yrs	40 - 60 yrs	> 60 yrs	< 40 yrs	40 - 60 yrs	> 60 yrs
	44	46	10	29	64	7

The results of the survey are reported as follows:

1 Objective conditions in the mining region and for the three clusters: This detailed analysis is also done for the non-mining villages. However, this is not reported here to save space.
2 Comparison of the QOL measures in mining and non-mining villages.
3 Differentiation of the QOL measures in the mining region across clusters and genders.
4 Subjective satisfaction has also been analysed across:
   - Income groups
   - Age groups
   - Migrants/local residents
   - Years of stay in the region
   - Marital status
   - Family type (nuclear/joint)
   - Stake in mining

However here we report only on satisfaction levels in the mining (alltogether and cluster wise) and non-mining regions, and between genders. The results of the survey analysis of the pilot test of version III is given in Section II.

Section II

A measure of the QOL (or well-being) of people in mining regions

In this section, we assess how far this tool enables us to comment on the above. The operational definition that we use for quality of life in our study is 'the satisfaction of a person with the conditions in the domains of life of importance to him/her'. We assume that the conditions – economic, social, political, biophysical, spiritual and biomedical – are different in mining and non-mining villages. The question that has guided this research is: how does mining influence the well-being of the people living in the mining region? How does mining contribute to, or detract from, the provision of these necessary conditions to the people living in the mining region?

Objective indicators in the mining region

For the economic domain, we have 25 objective indicators to reflect the following sub domains: Employment and work (2), Opportunities and safety nets (4), Infrastructure (8), Basic amenities (4), Asset ownership (4), Nutrition (2) and Average monthly income (1).

Table 4.20 Objective indicators–economic domain

Sub-domains	Number of objective indicators included
Employment and work	3
Opportunities and safety nets	4
Infrastructure	8
Basic amenities	4
Asset ownership	3
Nutrition	2
Earnings within household	1
Total	25

The table below summarizes the results of the survey carried out in mining villages.

Table 4.21 Indicators and results–economic domain

Objective indicators	Mining % Of respondents
Employment and work conditions	
Access to work	53
Regular paid employment	31.2
Secure job	23.8
Opportunity space and safety nets	
Ability to meet unforeseen expenses (upto Rs 5000) within a week	41.5
Access to traditional livelihood opportunities	32.1
Opportunities/access to learn new skills/develop old skills	16.0
Access to employment training programmes	11.4
Infrastructure	
Access to communication services (postal, e-mail, telegraph)	60.1
Electricity at home	93.8
Usage of public water	58.1
Usage of telephone	76.0
Home phone affordability	37.6
Usage of public transport system	91.4
Sufficient places to water and graze livestock	49.3
Access to and use of Government schemes (support, loan etc)	11.7
Basic amenities	
Access to toilets with in house	25
Access to water within house	44
Access to superior cooking fuel (gas)	70.1
Access to firewood within 100m of house for those who collect and use fuel wood	8.6
Asset ownership	
Own house	81
Land	72
Livestock	19.9
Nutrition	
Average expenditure on nutrition (Rs/month)	1951
Food sufficiency	95.3
Average household income (Rs/month)	4296

Highlights:

- The average income in the mining region is Rs 4296/month[9].
- Expenditure on various essential components reveals that maximum expenditure is on nutrition (50%).
- The non-working population is high in the mining regions (47%).
- 47% of respondents said they had no toilets; 25% had toilets inside the house.
- There is a substantial use of cooking gas, but there is also a large diversity in the fuel sources used. This could be because of:
    - Insecurity of fuel availability; e.g. gas is not delivered on time, or its availability is irregular.
    - Insecurity of income to pay for more expensive fuel sources.
    - Availability of agro waste, twigs in the household which makes the use of this rational.
- Fuelwood dependency has gone down. This can be argued to be a positive outcome as it reduces emissions, reduces indoor air pollution and is therefore an improvement in terms of environmental health.
- Of those who collect fuel wood, 6 % do so within 100 m of their houses. While 51% have to walk distances greater than 1 km.

Social domain

In the social domain, there are 16 objective indicators for the following sub-domains:

Table 4.22 Objective indicators–social domain

Sub-domains	Number of objective indicators included
Education level	2
Access to information	3
Family and community life	5
Choices regarding marriage and reproduction	2
Access to social security benefits	1
Access to sports facilities	1
Physical safety in the village	1
Alcoholism within family	1

[9] Field experience tells us that the income figures are a lower estimate.

The results of the survey in the social domain are given in the table below:

Table 4.23 Indicators and results–social domain

Objective indicators	Mining (% Of respondents)
Education	
Educational (secondary or more) achievements	42
Opportunities for children to go to school	96.7
Access to information	
Access to public library	24.4
Access to newspaper/TV	81.5
Access to radio	37.5
Family and community life	
Support of the extended family and/or friends	43.4
Good family life	83.5
Good relations with relatives	86.6
Community life	86.3
Able to express solidarity with others	98.2
Choices regarding marriage and reproduction	
Choice regarding marriage	46.6
Choice regarding number and spacing of children	56.7
Access to social security benefits	22.8
Access to sports facilities	54.5
Physical safety in the village	78.2
No alcoholism within family	79.1

Highlights:

- 42% of the respondents in the mining region are educated beyond secondary level and a very high percentage of respondents reported that their children had opportunities to go to school.
- There is a high access to information sources such as newspaper/TV, radio etc.
- About 50% of respondents have a choice regarding their marriage.
- 57% of the respondents reported free choice regarding the number and spacing of children.
- A very high percentage of respondents reported being able to express solidarity with others.
- Access to social security benefits is very low.
- A high percentage of respondents reported no alcoholism within the family.

Political domain

In the political domain, there are 16 indicators for the following sub-issues:

Table 4.24 Objective indicators–political domain

Sub-domains	Number of indicators
Participation	4
Engagement in civic life	4
Political and legal rights	4
Good governance	4
Total	16

The results are given in the table below:

Table 4.25 Indicators and results–political domain

Objective indicators	Mining (% Of respondents)
Participation	
Participation in local politics	19.3
Involvement in monitoring critical issues in village	36.8
a) HH-level participation	92.8
b) Village/municipal level	22.1
Engagement in civic life	
a) By voting	99.2
b) By being part of cooperative society	17.7
c) Making demands of public services	17.7
d) By running for a public position/standing for election	2.3
Political and legal rights	
Awareness of legal rights	31.9
Access to legal aid if need be	33.2
Afford legal aid if need be	26.4
Awareness of political rights	23.7
Good governance	
Effective rule enforcement	38.0
Absence of graft	45.6
Stability	32.8
Accountability	33.0

Highlights:

- A high percentage of households in the mining region report participation in household level decision making but village level decision making is only about 22%. Except for voting, engagement in civic life is minimal in the region. There is however considerable involvement in monitoring critical issues in the village.
- A larger percentage of households in the mining region report dealings of the government as honest, stable and accountable.
- 51% of the households in the mining region feel that there is misuse of authority in Goa.
- 32% reported awareness of legal rights and even less of political rights (24%).

Biomedical domain

In this domain, 21 objective indicators are developed for the following sub-domains:

(1) Health facilities - 6

(2) Economic ability to maintain health - 3

(3) Health status - 12

Table 4.26 Indicators and results–biomedical domain

Objective indicators	Mining % Of respondents
Health facilities	
Nearby family welfare centre (located within 10 km radius)	64.7
Nearby maternity/child care clinics/centres (located within 10 km radius)	55.8
Dental clinics nearby	37.0
Primary health care facilities nearby (within 5 km radius)	68.1
Availability of alternative/traditional medical system	26.0
Easy availability of western/modern medicines	31.2
Economic ability to maintain health	
Do you have any of the following?	
1) Medical insurance (either public/private)	7.0
2) Medical coverage	8.0
Can you afford any of the immunization programmes not supported by the government?	26.3

Continued

Table 4.26 Continued

Objective Indicators	Mining (% of respondents)
Health status	
No health problem	43.2
Enough sleep/rest (to have adequate stamina to carry out daily activities)	87.1
Good appetite and digestion	92.8
Non-dependence on medicines (in order to undertake daily activities)	24.5
Experience of emotional compatibility with those important	95.6
Family free from physical/mental disabilities	62.8
Free from mental stress, anxiety etc.	67.9
Family free from acute/chronic illness	70.0
Good reproductive health/fertility	79.0
Good vigour and stamina to carryout daily activities	61.2
Good self-confidence	81.7
Workplace free from health and safety risks	76.4

Highlights:

- 43% report no health problems. Of those who do have problems, the maximum number respondents reported the occurrence of colds. Focus group meetings as well as other sources suggest that there are various cases of tuberculosis in the region, but this was not reported[10].
- Households in the mining region also seem to have better health facilities compared to the non-mining region. This is a positive contribution made by the mining companies as reported from the field.
- There are also a number of health camps provided by the mining companies.

Biophysical domain

In the biophysical domain, 12 indicators have been developed for the following sub-domains:

(1) Land quality: 5
(2) Air quality: 1
(3) Water: 2
(4) Noise and vibrations: 2
(5) Aesthetic environments: 4

[10] This is often the case in surveys of this kind as TB has some kind of stigma attached with it. Unfortunately there were no reports that we could obtain from the Primary Health Centres.

Table 4.27 Indicators and results–biophysical domain

Objective indicators	Mining % of respondents
Land	
Good land quality	27
Positive changes in natural landscape	19.8
No change in number of plants	25.4
No change in number of animals	17.4
Not exposed to calamities like floods,land slides,droughts etc..	78.9
Air	
Good air quality	45.5
Water	
Good quality of drinking water	83.5
Good quality water for other domestic purposes	80.2
Noise and vibrations	
Freedom from noise (loud and constant)	50.6
Living place free from man-made vibrations	63.5
Aesthetic environment	
Work/living place clean	84.4
Work/living place accident-free (vehicular)	74.7
Open/green spaces around place of work	68.1
Open/green spaces around living place	77.8

Highlights:

- 38% of respondents said that land quality in the mining region is bad.
- 25% of the respondents said there was no change in natural landscape; 14% said there were bad changes and 20% said there were good changes.
- 65% reported reduction in plant cover.
- 21% reported exposure to floods, landslides.
- 35% reported bad air quality.
- 50% reported loud and constant noise and 35% reported vibrations.
- Over 75% reported having green places around living area.

Spiritual domain

The responses for the spiritual domain are given below:

Table 4.28 Indicators and results–spiritual domain

Objective indicators	Mining (% Respondants)
Involvement in festivals/religious ceremonies	94.1
Place of worship close by	85.1
Strong personal beliefs	98.2
Faith in God	99.7

Objective indicators: a gender-based analysis in the mining region

The tables below summarize the results from the survey across gender in mining villages. Here only those indicator responses that can be differentiated across gender are included, as some apply to the household as a whole.

Table 4.29 Indicators and results across gender–economic domain

Economic domain	Mining % of respondents	
	Male	Female
Employment and work conditions		
Access to work	87.5	14.5
Regular paid employment	44.7	12.1
Secure job	36.6	3.7
Opportunity space and safety nets		
Access to traditional livelihood opportunities	39.6	24.1
Opportunities/access to learn new skills/develop old skills	17.4	14.5
Access to employment training programmes	16.8	5.4
Access to and use of government schemes (support, loan etc)	14.4	8.7

It is evident that women do very poorly in the employment and work sub-domain. In opportunities to diversify and learn new skills also, they do very poorly. Both men and women benefit little from government schemes, but the women benefit less. The gender gap is also observed in Table 4.30 below with regard to education, marital and reproductive choices and access to social security benefits.

Table 4.30 Indicators and results across gender–social domain

Social domain	Mining (% of respondents)	
	Male	Female
Education		
Education (secondary or more)	53	29.9
Choices regarding marriage and reproduction		
Choice regarding marriage	61.3	31
Choice regarding number and spacing of children	74.1	38
Access to social security benefits	27.2	17.9

Table 4.31 Indicators and results across gender–political domain

Political domain	Mining (% of respondents)	
	Male	Female
Participation		
Participation in local politics	32.3	5.3
Involvement in monitoring critical issues in village	53.5	18.7
a) HH-level participation	93.1	92.5
b) Village/municipal level	38.1	4.8
Engagement in civic life		
a) By voting	99	99.5
b) By being part of cooperative society	32.2	2.1
c) Making demands of public services	29.2	5.34
d) By running for a public position/standing for election	3.47	1.07
Political and legal rights		
Awareness of legal rights	31.2	32.6
Access to legal aid if need be	38.6	61.4
Afford legal aid if need be	32	20.4
Awareness of political rights	34.3	12.3
Good governance		
Effective rule enforcement	43.3	32.3
Absence of graft	49.5	41.6
Stability	37.8	27.3
Accountability	42.1	21.7

The gender difference in measures relating to the political domain is also evident. Women fare less well than men in every indicator in this domain.

Table 4.32 Indicators and results across gender–biomedical domain

Biomedical domain	Mining % of respondents	
	Male	Female
Health facilities		
No health problem	34.1	50.8
Enough sleep/rest (to have adequate stamina to carry out daily activities)	87.1	87.1
Good appetite and digestion	92.1	93.5
Non-dependence on western/modern medicines (in order to undertake daily activities)	27	21.7
Experience of emotional compatibility with those important	94.1	97.3
Family free from physical/mental disabilities	59.7	66.1
Free from mental stress, anxiety etc	63.9	72.2
Family free from acute/chronic illness	67.5	72.7
Good reproductive health/fertility	68.4	85.1
Good vigour and stamina to carry out daily activities	67.6	54.1
Good self-confidence	83.2	80
Workplace free from health and safety risks	69.8	83.6

Women seem to do much better in the biomedical domain. They report an equal if not better than health status as compared to men. This needs further investigation in the light of the existing literature on the subject (Dasgupta et al. 1998). It is well established that morbidity reporting improves with the level of education. Hence the lower reporting by women may reflect their lower literacy levels. Also episodes that are treated and hospitalized may be better reported. This may indicate lesser chances of women's illnesses being treated, also given the fact that men get attention in medical facilities provided by mining companies that women do not have access to. This difference may be significant if the different types of morbidity are considered. Thus, Murray (1998) suggests that 3 different types of morbidity be distinguished because each class has a different set of determinants (p. 143). These classes are:

- Morbidity that is self-perceived[11] but which cannot be observed, e.g., pain and suffering of an individual, and is dependent on the individual's perception. The determinants of this class are individual education and community culture which influences perception and approach to pain and suffering; prevalence of undetected disease and the exposure to health services.

[11] Murray distinguishes between self-perception and self-reporting. A person can report illness after someone else has observed it even if unable to perceive it.

- Observed[12] morbidity that is not perceived, e.g., hypertension, silent myocardial ischaemia, and many chronic infectious diseases. The existence of this class of morbidity can be explained by differences in access to health services.
- Morbidity which can be self-perceived and observed (p. 136). The existence of differences between self-perceived and observed levels within this class have been explained through the following: the difference between an ideal state of health in mind and the individual's perception of where he/she is in relation to it; perceived predisposition to morbidity; cultural and social beliefs affecting willingness to accept sick roles; stresses and psychological reasons somatasized into physical symptoms; mis-reporting (Murray and Chen 1990).

Further Murray (1998) points to the potential that always exists to measure observed health and suggests that one approach to measure self-perceived morbidity is to measure the gap between observed health status and health ideals, where both are seen as positive measures of health. The distance between the two is self-perceived morbidity, a negative measure of health. At any point of time, 2 individuals in different regions with the same health status, but with differing levels of health ideals, will have differing levels of self-perceived morbidity. Similarly, individuals in the same region, sharing the same ideals but with differing observed health status will have differing self-perceived morbidity. Health ideals capture the complex of cultural, social, educational and individual perceptions factors. The determinants of health ideals are the cultural model of health and development, education and exposure to health services. The determinants of observed health status are levels of nutrition, access to health care and education. Given that these objective indicators are so very different for men and women in the study area, the fact that their reported health status is similar, requires further investigation.

[12] Observation here includes a wide range of tests and diagnostic procedures.

Table 4.33 Indicators and results across gender–biophysical domain

Biophysical domein	Mining % of respondents	
	Male	Female
Land		
Good land quality	27.3	26.7
Positive changes in natural landscape	23.9	15.3
No change in number of plants	19.4	31.9
No change in number of animals	14.9	20
Not exposed to calamities like floods, land slides, droughts etc.	75.2	82.9
Air		
Good air quality	45	46
Water		
Good quality of drinking water	83.5	83.5
Good quality water for other domestic purposes	80.2	80.2
Noise and vibrations		
Freedom from noise (loud and constant)	52.5	48.7
Living place free from man-made vibrations	63.9	63.1
Aesthetic environments		
Work/living place clean	79.5	89.7
Work/living place accident-free (vehicular)	70	79.7
Open/green spaces around place of work	65.3	72.5
Open/green spaces around living place	78.6	77

Here too, the differences are not major. The views of women support the issues raised in the focus group meetings, wherein they felt that the major issues affecting their lives were scarcity of groundwater and siltation of fields. In addition, they complained about lack of medical facilities (one doctor visiting the village once a week, no pharmacy in the area), and unemployment.

Table 4.34 Indicators and results across gender–spiritual domain

Spiritual domain	Mining % of respondents	
	Male	Female
Involvement in festivals/religious ceremonies	98	89.8
Place of worship close by	89.6	80.2
Strong personal beliefs	98.5	97.9
Faith in God	99.5	100

Objective indicators across clusters

The table below summarizes the economic domain results from the survey carried out across three clusters of mining villages. The three clusters have had mining activity over different periods of time. Cluster I >40 years, cluster

II >25 years and cluster III >15 years of mining activity. Cluster I has a number of mines that are closing down; cluster II has active mining, mostly old mines with some new mines. Cluster III has more recent mines with new mines opening up.

Economic domain

Table 4.35 Indicators and results across clusters—economic domain

Economic domain	Cluster I	Cluster II	Cluster III
	% Of respondents		
Employment and work conditions			
Access to work	53	55	49
Regular paid employment	28.3	35.1	27.8
Secure job	21.2	29.1	17.8
Opportunity space and safety nets			
Ability to meet unforseen expenses (upto Rs 5000) within a week	40.5	46.4	33
Access to traditional livelihood opportunities	37.1	27.5	35.2
Opportunities/access to leam new skills/develop old skills	25	11	14.4
Access to employment training programmes	19.8	6.1	11.1
Infrastructure			
Access to communication services (postal, e-mail, telegraph)	60.9	62.1	54.9
Electricity at home	97.4	96.2	84.6
Usage of public water	50	59.9	64.8
Usage of telephone	85.3	79.1	57.8
Home phone affordability	38.8	39.6	31.8
Usage of public transport system	96.5	94	79.3
Sufficient places to water and graze livestock	62.3	45.6	38.4
Access to and use of government schemes (support, loan etc)	15.5	11.2	7.7
Basic amenities			
Access to toilets within house	51	54	54
Access to water within house	43.1	50	37.8
Access to superior cooking fuel (gas)	81	70.9	54.9
Access to firewood within 100m of house for those who collect and use fuel wood	39.7	47.9	37.3
Asset ownership			
Own house	85	80	77
Land	73	83	52
Livestock	23.3	19.9	15.7
Average expenditure on nutrition (Rs/month)	2004	1989	1805
Food sufficiency	97.4	96.7	90
Average household income (Rs/month)	4670	4345	3723

Main findings:

- Majority of the people belong to the Rs 2000-5000 income group with almost 50% of the respondents falling in this income bracket in all three clusters.
- The percentage of people with monthly income <Rs 2000 is higher in cluster III, then followed by cluster II and I.
- The people in the income group Rs 2000-5000 are comparatively higher in cluster I, followed by cluster II and then III.
- Cluster I has more respondents in the >Rs 5000 income group, followed by cluster II and III, however the percentages are very low in all clusters.
- Cluster II does consistently better in all indicators of employment and work and in the meeting of unforeseen expenses.
- Cluster I does better in indicators of opportunities for diversification.
- Cluster I and II are better off in their access to infrastructure.
- Cluster II is better off in terms of basic amenities.
- Cluster I is better off in terms of asset ownership.

Worker distribution cluster-wise

The worker distribution is given in the charts below.

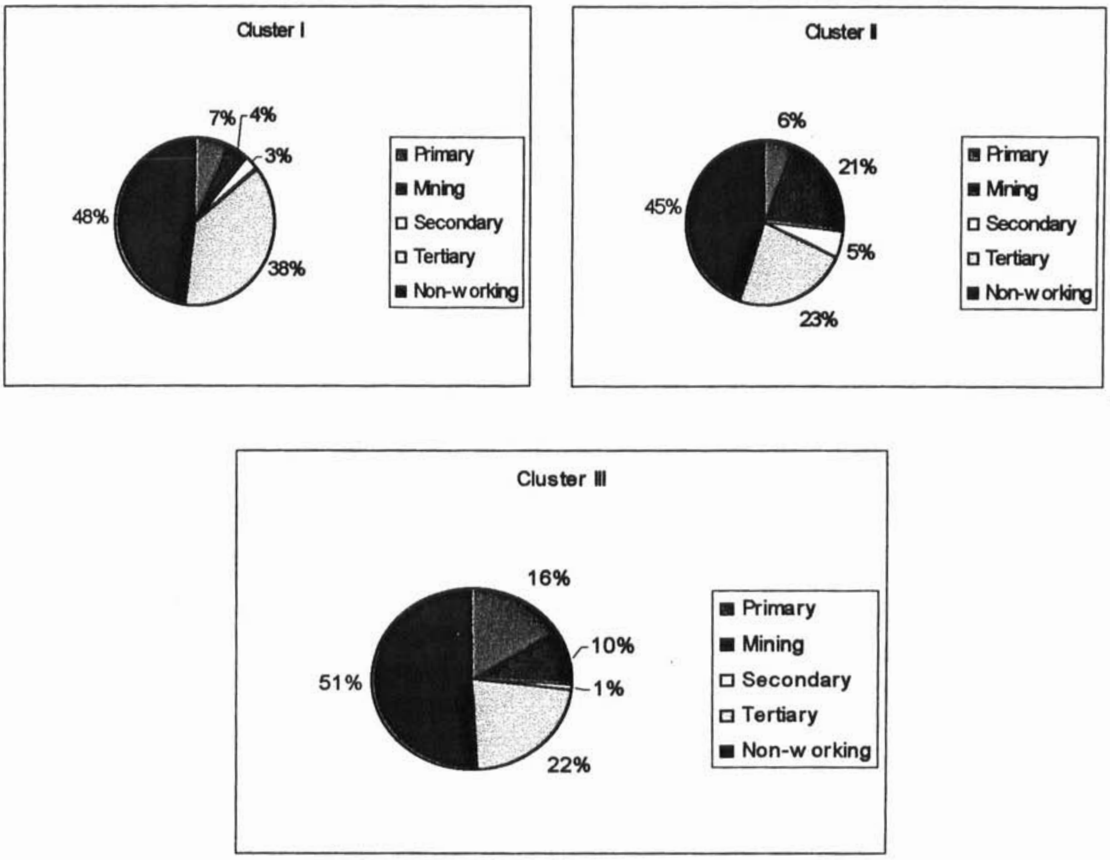


Figure 4.2 Cluster-wise worker distribution

- Almost 26% of the respondents are involved in the primary (inclusive of mining) sector in clusters II and III as compared to only 11% in cluster I.
- The non-working population (unemployment/working at home/retired) is high in cluster III (51%) followed by cluster I (48%) and then cluster II (45%).
- Of the primary sector, the percentage in mining is highest in cluster II at 77%, the balance being engaged in the agricultural sector, followed by cluster III and I with 63% and 36%, respectively. This in a way indicates the decrease of agriculture in cluster II and III as against cluster I

which still shows a larger number of people engaged in agriculture than in mining activity from within the primary sector.

Fuel sources

- Large diversity of fuel sources perhaps because of:
  1 Insecurity of fuel availability
  2 Insecurity of income to pay for more expensive fuel sources
  3 Availability of agro waste
- Households using gas are more in cluster I and II (81% and 71%, respectively) as compared to cluster III (55%). Even the use of kerosene is higher in cluster I, followed by II and then III.
- Households using fuelwood are more in cluster III (60%) followed by both cluster II and I at 55%.
- A higher single dependence on fuelwood is observed in cluster III (32%) as compared to a very low 7% and 8% in cluster I and II.
- Fuelwood collection is closer to the place of residence in cluster III as compared to the other two clusters, so also is the purchase of fuelwood at 51% followed by 47% and 45% in cluster I and II. This information is summarized in the figure below:

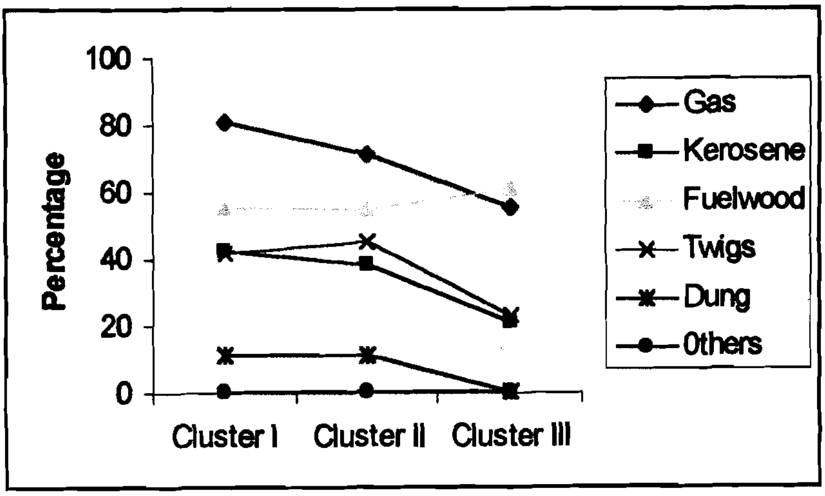


Figure 4.3 Use of different fuels across clusters

Social domain

Table 4.36 Indicators and results across clusters–social domain

Social domain	Cluster I	Cluster II	Cluster III
		(% Of respondents)	
Education			
Educational (secondary or more) achievement	52	38	38
Opportunities for children to go to school	99.1	97.1	92.3
Access to information			
Access to public library	31	27.5	9.9
Access to newspaper/TV	94	91.2	68.1
Access to radio	44	40.7	23.1
Family and community life			
Support of the extended family and/or friends	34.5	41.2	59.3
Good family life	84.5	81.3	86.8
Good relations with relatives	87.9	86.2	85.7
Community life	84.5	87.3	86.7
Able to express solidarity with others	97.4	98.4	98.9
Choices regarding marriage and reproduction			
Choice regarding marriage	51.7	42.2	48.9
Choice regarding number and spacing of children	57.8	59.7	49.5
Access to social security benefits	22.8	21	26.4
Access to sports facilities	61.2	50.5	53.8
Physical safety in the village	81.1	70.3	90.2
No alcoholism within family	85.3	77.8	73.6

The survey reveals the social advances in cluster I relative to clusters II and III. The differences in educational achievements are given in Table 4.37 below.

Table 4.37 Difference in educational achievements

Clusters	Illiterate %	Primary %	Secondary %	Post-secondary %	Vocational %
Cluster I	19	29	43	6	3
Cluster II	25	37	34	3	1
Cluster III	43	19	33	4	1

- A high number of respondents are found illiterate in cluster III at 43% as compared to 25% and 19% in cluster II and I respectively.
- 37% respondents in cluster II and 29% in cluster I are educated upto primary level, with only 19% in cluster III.
- 43%, 34% and 33% of the respondents are educated upto secondary level in clusters I, II and III respectively.

- Only 6%, 3% and 4% in clusters I, II and III respectively are educated beyond secondary level.
- 3% of the population in cluster I has vocational/technical education.

Thus cluster I has better educational achievements as compared to cluster II and III.

Political domain

The political domain results are given in the table below:

Table 4.38 Indicators and results across clusters–political domain

Political domain	Cluster I	Cluster II	Cluster III
	(% Of respondents)		
Participation			
Participation in local politics	22.4	21.4	11.1
Involvement in monitoring critical issues in village	44	37.9	25.3
a) HH level participation	96.6	91.2	91.2
b) Village/municipal level	30.2	23.1	9.9
Engagement in civic life			
a) By voting	100	98.9	98.9
b) By being part of cooperative society	22.4	19.8	7.7
c) Making demands of public services	25	18.1	7.7
d) By running for a public position/standing for election	2.6	3.3	0
Political and legal rights			
Awareness of legal rights	31.9	31.3	33
Access to legal aid if need be	51.7	19.8	36.3
Afford legal aid if need be	31.3	23.2	26.7
Awareness of political rights	22.6	19.2	34.1
Good governance			
Effective rule enforcement	43.9	39.6	27.5
Absence of graft	42.1	50.6	40.2
Stability	32.6	37.4	23.4
Accountability	32.6	34.4	31

- Overall cluster I shows higher participation in political life, also a higher percentage of them reported misuse of authority in Goa.
- In cluster II respondents feel that the government is more honest, stable and accountable compared to clusters I and III.

- About 80% of the respondents in all clusters support traditional ways to prevent and resolve conflicts, preferring the *panchayat* followed by the police and then courts.
- Respondents in cluster I seem actively involved in conflict resolution as compared to the other two clusters.
- Legal awareness of rights is almost same across all clusters but access to and affordability of legal aid is higher in cluster I followed by cluster III; however a higher awareness of political rights is observed in cluster III.

Bio-medical domain

Table 4.39 Indicators and results across clusters–biomedical domain

Biomedical domain	Cluster I	Cluster II	Cluster III
		% Of respondents	
Health facilities			
Nearby family welfare centre (located within 10 km radius)	93	61.5	35.2
Nearby maternity/child care clinics/centres (located within 10 km radius)	88.8	48.9	27.5
Dental clinics nearby	70.7	28	12.1
Primary health care facilities nearby (within 5 km radius)	93.1	69.8	33
Availability of alternative/traditional medical system	33.6	22.7	23.1
Easy availability of western/modern medicines	44.8	20.4	35.2
Economic ability to maintain health			
Do you have any of the following?			
1) Medical insurance (either public/private)	13	3	6
2) Medical coverage	4	10	9
Can you afford any of the immunization programmes not supported by the government?	28.4	21.9	32.2

Continued

Table 4.39 Continued

Biomedical domain	Cluster I	Cluster II	Cluster III
Health status			
No health problem	44	44	40.7
Enough sleep/rest (to have adequate stamina to carry out daily activities)	85.3	91.2	81.3
Good appetite and digestion	94.8	94.5	86.8
Non-dependence on medicines	74.1	78.9	70.5
Experience of emotional compatibility with those important	94	96.1	96.7
Family free from physical/mental disabilities	81	56.7	51.6
Free from mental stress, anxiety etc	64.7	68.1	71.4
Family free from acute/chronic illness	76.5	73.1	55.6
Good reproductive health/fertility	92	73.8	77.2
Good vigour and stamina to carry out daily activities	64.9	63.6	51.7
Good self-confidence	85.2	81.2	78
Workplace free from health and safety risks	75.4	75	80.7

Highlights:

- Cluster I shows better biomedical conditions compared to clusters II and III.

  We present below a differentiated analysis on reported health problems.

Table 4.40 A differentiated analysis of reported health problems

Particulars		Mining	Non-mining	Cluster I	Cluster II	Cluster III
Across GENDER	Male	58.4	50	58.5	63.7	48.1
	Female	41.6	50	41.5	36.3	51.9
Across AGE GROUP	< 40	41.6	30.6	40	41.2	44.4
	40-60	46.6	63.9	44.6	47.1	48.1
	> 60	11.8	5.6	15.4	11.8	7.4
By YEARS OF STAY	< 10	11.3		7.7	11.8	14.8
	10-20	10	16.7	18.5	5.9	7.4
	> 20	78.7	83.3	73.8	82.4	77.8
Across INCOME GROUP	< 2000	32.7	19.4	33.8	32.7	31.4
	2000-5000	42.4	50	36.9	42.6	49
	> 5000	24.9	30.6	29.2	24.8	19.6
By EDUCATIONAL LEVEL	Illiterate	27.6	36.1	21.5	23.5	42.6
	Upto secondary	29.9	13.9	24.6	38.2	20.4
	Post-secondary and vocational	57.7	58.7	58.3	57.4	57.1
By RESIDENTIAL STATUS	Local resident	71.5	77.8	84.6	70.6	57.4
	Migrant	28.5	22.2	15.4	29.4	42.6

Table 4.41 Health expenses (Rs/per month)

Particulars	Mining	Non-mining	Cluster I	Cluster II	Cluster III
Expenditure on nutrition	1951	1990	2004	1989	1805
Expenditure on health	303	439	380	265	281

Biophysical domain

Table 4.42 Indicators and results across clusters–biophysical domain

Biophysical domain	Cluster I	Cluster II	Cluster III
	% Of respondents		
Land			
Good land quality	35	17.5	33.7
Positive changes in natural landscape	28.7	16.3	15.4
No change in number of plants	21.7	23.1	34.8
No change in number of animals	13	15.4	27
Not exposed to calamities like floods, land slides, droughts etc.	83.6	78.4	76.7
Air			
Good air quality	66.4	31.9	46.2
Water			
Good quality of drinking water	93.9	80.2	76.9
Good quality water for other domestic purposes	88.9	76.4	76.9
Noise and vibrations			
Freedom from noise (loud and constant)	60.3	48.4	42.9
Living place free from man-made vibrations	80.2	60.4	48.4
Aesthetic environments			
Work/living place clean	96.6	77.5	82.4
Work/living place accident free (vehicular)	73	73.5	79.1
Open/green spaces around place of work	81.4	53.7	80.8
Open/green spaces around living place	89.7	69.1	80.2

- In general, cluster I is better off environmentally than the other two.

Spiritual domain

The responses for the spiritual domain are given below:

Table 4.43 Indicators and results across clusters–spiritual domain

Spiritual domain	Cluster I	Cluster II	Cluster III
	% Of respondents		
Involvement in festivals/religious ceremonies	93.1	92.3	98.9
Place of worship close by	96.6	80.8	93.4
Strong personal beliefs	99.1	100	98.9
Faith in God	99.1	100	79

Combining objective indicators

Indices are developed in order to be able to arrive at more aggregated measures of the objective conditions and placed on a scale. The process of combining involved the following:

1. Initially relative scores corresponding to each of the indicators of sub-domains of all the six main domains are computed by using the maximum and minimum values as done in the HDR to arrive at a Human Development Index[13]. Minimum and maximum values for all indicators were obtained from these calculations and were assigned values ranging from 0 to 1 for responses within that sub-domain, i.e., the response with the lowest indicator value was assigned 0 and that with the highest value assigned 1. This relative score is computed using the actual values of the mining region, non-mining region, three clusters and gender-wise values. The index for each group it thus its position between the highest (assigned 1) and the lowest (assigned 0) value in that particular domain as captured from the responses of those surveyed.
2. Average scores of all the sub-domains are computed using the relative scores of all the indicators within the sub-domains.
3. Average scores of all the domains are computed using the sub-domain indices.
4. Finally, a composite index of the overall objective conditions is computed by averaging the indices of all domains.

The performance scale has not been controlled, but this can be done for evaluative commentary as is done in Prescott-Allen, 1997.

[13] Relative score= (actual value-minimum value)/(maximum value-minimum value).

Mining and non-mining areas

In the table below we compare objective QOL measures across mining and non-mining and the three clusters of our study.

Table 4.44 Objective condition indices across mining and non-mining and the three clusters

Domains and sub-domains	Mining	Non-mining	Cluster I	Cluster II	Cluster III
Employment and work conditions	0.51	0.53	0.46	0.61	0.41
Opportunity space and safety nets	0.37	0.73	0.62	0.27	0.24
Access to infrastructure	0.54	0.64	0.73	0.62	0.11
Access to basic amenities	0.46	0.62	0.42	0.69	0.04
Asset ownership	0.48	0.78	0.72	0.58	0
Nutrition	0.73	0.58	1	0.92	0
Average income	0.36	1	0.6	0.39	0
ECONOMIC INDEX	0.49	0.7	0.65	0.58	0.11
Educational achievements	0.52	0.64	0.86	0.49	0.13
Access to information	0.57	0.65	0.9	0.77	0
Family and community life	0.53	0.62	0.54	0.47	0.63
Choices regarding marriage and reproduction	0.42	0.67	0.5	0.39	0.36
Access to social security benefits	0.79	0.1	0.79	0.71	0.96
Access to sports facilities	0.11	0.57	0.3	0	0.09
Physical safety in the village	0.54	0.43	0.65	0.23	1
No alcoholism	0.87	0.36	1	0.84	0.75
SOCIAL INDEX	0.54	0.51	0.69	0.49	0.49
Participation	0.51	0.38	0.76	0.5	0.23
Engagement in civic life	0.46	0.44	0.61	0.48	0.24
Political and legal rights	0.42	0.74	0.53	0.28	0.55
Good governance	0.72	0.21	0.77	0.86	0.37
POLITICAL INDEX	0.53	0.44	0.67	0.53	0.35
Land	0.38	0.62	0.41	0.25	0.61
Air	0.21	0.85	0.53	0	0.22
Noise and vibrations	0.39	0.8	0.85	0.3	0
Aesthetic environment	0.35	0.91	0.69	0.06	0.51
Water	0.29	1	0.84	0.09	0.02
ENVIRONMENTAL INDEX	0.32	0.84	0.66	0.14	0.27
Health facilities	0.4	0.47	0.84	0.29	0.05
Economic ability to maintain health	0.45	0.49	0.46	0.33	0.58
Health status	0.55	0.38	0.73	0.65	0.46
BIOMEDICAL INDEX	0.47	0.45	0.68	0.42	0.36
SPIRITUAL INDEX	0.67	0.71	0.82	0.58	0.69
OVERALL	0.5	0.61	0.7	0.46	0.38

Highlights:

- The mining region performs worse on each of the domains and overall in objective QOL measures relative to the non-mining villages; this is with the exception of the political domain, where the mining villages score higher on participation and good governance indicator values.
- Within mining villages, cluster I does consistently better than cluster II and cluster II better than cluster III. Age of mining seems to make a difference as originally hypothesized. As mining incomes grow, diversification takes place, and the villagers also move up a number of social indicator values. Cluster I also performs better than non-mining villages in all domains and in overall objective measures. It is only in the economic and the biophysical domain, that the non-mining villages outperform cluster I villages.

This comparison is also done across gender in both mining and non-mining regions. The gender gap is more pronounced in the mining villages relative to non-mining. Curiously, however, women are worse off than men in terms of objective measures in all domains in the non-mining regions. In the mining regions, they are worse off than males in the economic, social, spiritual and political domains, but not in the biomedical and biophysical.

Gender-wise comparison in mining and non-mining regions

Table 4.45 Performance across gender in mining and non-mining villages

Sub-domains and their indices	Mining		Non-mining	
	Male	Female	Male	Female
Employment and work conditions	0.9	0	0.88	0.32
Opportunity space and safety nets	0.55	0.2	0.93	0.6
Access to infrastructure	0.56	0.52	0.73	0.61
Access to basic amenities	0.46	0.46	0.62	0.62
Asset ownership	0.48	0.48	0.78	0.78
Average income	0.36	0.36	1	1
Nutrition	0.73	0.73	0.58	0.58
ECONOMIC INDEX	0.58	0.58	0.58	0.58
Educational achievements	0.7	0.33	0.8	0.5
Access to information	0.57	0.57	0.65	0.65
Family and community life	0.55	0.5	0.52	0.71
Choices regarding marriage and reproduction	0.8	0	1	0.4
Access to social security benefits	1	0.56	0.22	0
Access to sports facilities	0.11	0.11	1	0.2
Physical safety in the village	0.65	0.41	0	0.79

Continued

Table 4.45 Continued

Sub-domains and their indices	Mining		Non-mining	
No alcoholism	0.79	0.95	0	0.66
SOCIAL INDEX	0.65	0.43	0.52	0.49
Participation	0.87	0.13	0.66	0.14
Engagement in civic life	0.67	0.24	0.6	0.3
Political and legal rights	0.57	0.43	1	0.52
Good governance	0.98	0.42	0.31	0.11
POLITICAL INDEX	0.77	0.31	0.64	0.27
Land	0.28	0.49	0.47	0.75
Air	0.2	0.22	1	0.73
Noise and vibrations	0.44	0.35	0.92	0.71
Aesthetic environment	0.2	0.53	0.86	0.96
Water	0.29	0.29	1	1
BIOPHYSICAL INDEX	0.28	0.38	0.85	0.83
Health facilities	0.43	0.36	0.44	0.5
Economic burden of maintaining health	0.47	0.47	0.56	0.56
Health status	0.53	0.71	0.46	0.42
BIOMEDICAL INDEX	0.48	0.51	0.49	0.49
SPIRITUAL INDEX	0.85	0.48	0.81	0.61
OVERALL	0.6	0.42	0.68	0.56

The information for the sub-domains is summarized in the table below.

Table 4.46 Gender-wise objective indices

	Mining		Non-mining	
Domains	Male	Female	Male	Female
Economic index	0.58	0.39	0.79	0.64
Social index	0.65	0.43	0.52	0.49
Political index	0.77	0.31	0.64	0.27
Biophysical index	0.28	0.38	0.85	0.83
Biomedical index	0.48	0.51	0.49	0.49
Spiritual index	0.85	0.48	0.81	0.61
Overall	0.6	0.42	0.68	0.56

Cluster-wise comparison of objective indicators

The figure below provides a cluster-wise comparison of indices across clusters. In the economic domain, clusters I and II are close; in the social, cluster I is doing much better than II and III; in the political, cluster I does better than II and II better than III; in the biophysical, cluster II does the worst; overall, cluster I does better than II and II better than III.

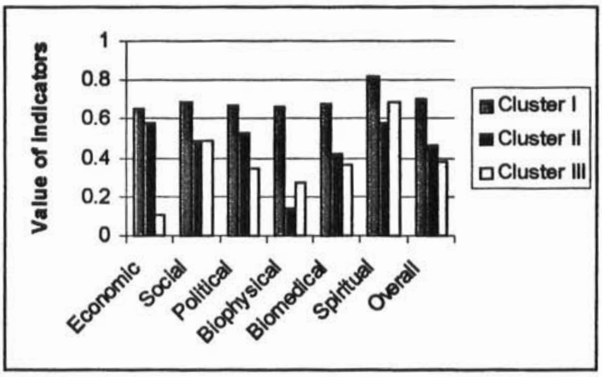


Figure 4.4 Cluster wise comparison of objective indicators

Finally, the table below provides a summary of the objective measures of QOL.

Table 4.47 Objective condition indices: a cross-comparison

Domains	Mining	Non-mining	Cluster I	Cluster II	Cluster III
Economic index	0.49	0.7	0.65	0.58	0.11
Social index	0.54	0.51	0.69	0.49	0.49
Political index	0.53	0.44	0.67	0.53	0.35
Biophysical index	0.32	0.84	0.66	0.14	0.27
Biomedical index	0.47	0.45	0.68	0.42	0.36
Spiritual index	0.67	0.71	0.82	0.58	0.69
Overall	**0.5**	**0.61**	**0.7**	**0.46**	**0.38**

Thus on a performance scale of 0-1, cluster I villages do best of all in overall objective conditions, followed by the non-mining villages; cluster III villages do the worst.

Subjective indicators

In this section, subjective satisfaction level mean scores are compared with respect to various factors. Subjective satisfaction is measured in this study using a five-point scale with the score 1 rating as very dissatisfied, 2 Dissatisfied, 3 Neither satisfied nor dissatisfied, 4 Satisfied, and, 5 Very satisfied.

The above scales are aggregated and the results are interpreted as follows. i.e. scores ranging

< 2.5	Dissatisfied
2.5–3.5	Neither satisfied nor dissatisfied
>/= 3.5	Satisfied.

The t-test for equality of means and one-way analysis of variance (ANOVA) are used to compare whether any statistically significant difference exits between the mining and the non-mining regions.

Results

Table 4.48 Satisfaction levels across domains for the whole mining region

	Mining	
Domains	Mean	Std Error
Economic	3.32	.03
Social	3.66	.02
Political	3.52	.02
Environmental	3.56	.03
Biomedical	3.56	.02
Spiritual	4.17	.03

We also comment briefly on satisfaction levels across residency status, income and gender.

Are migrants more satisfied than locals?

Table 4.49 Satisfaction level by residential status within mining region

	Local resident		Migrant		Significance
Domains	Mean	Std Error	Mean	Std Error	
Economic	3.27	.03	3.44	.05	$P<0.05$
Social	3.66	.02	3.66	.04	
Political	3.51	.03	3.53	.04	
Environmental	3.59	.04	3.49	.06	
Biomedical	3.53	.03	3.65	.04	$P<0.05$
Spiritual	4.21	.03	4.08	.05	$P<0.05$
All together	3.63	.02	3.64	.03	

Highlights:

- Migrants are more satisfied with jobs, income, sanitation and fuel affordability than local people but less satisfied with children's education and housing than local people.
- Migrants are less satisfied with participation levels and access to places of worship than local people.
- Migrants are more satisfied with emotional life and safety and health in work place than local people.
- There is no statistically significant difference in overall satisfaction levels between migrants and local people.

Is there a relationship between satisfaction levels and income?

Table 4.50 By income

	< Rs 2000		Rs 2000-5000		> Rs 5000		Significance
Domains	Mean	Std Error	Mean	Std Error	Mean	Std Error	
Economic	2.97	.05	3.34	.03	3.65	.04	P<0.05
Social	3.47	.04	3.65	.02	3.89	.04	P<0.05
Political	3.43	.04	3.51	.03	3.61	.05	P<0.05
Environmental	3.49	.07	3.58	.04	3.58	.06	
Biomedical	3.46	.05	3.58	.03	3.64	.05	P<0.05
Spiritual	4.15	.05	4.19	.04	4.16	.06	
Overall	3.50	.03	3.64	.02	3.75	.03	P<0.05

These results reveal that in general, the rich are more satisfied with life than the poor.

Are those with a stake in mining more satisfied than those without?

Table 4.51 Satisfaction scores among those who have stake/no stake in mining

	No stake		Stake in mining		Significance
Domains	Mean	Std Error	Mean	Std Error	
Economic	3.29	.03	3.49	.06	P<0.05
Social	3.64	.02	3.79	.05	P<0.05
Political	3.52	.02	3.48	.07	
Environmental	3.58	.03	3.38	.10	P<0.05
Biomedical	3.57	.03	3.53	.07	
Spiritual	4.18	.03	4.09	.07	
Overall	3.63	.02	3.63	.04	

In both the economic and social domains those engaged in mining have higher satisfaction levels, relative to those not engaged in mining; this is reversed for satisfaction with the environmental domain.

Is there a difference across views with those who have been in the region longer?

Table 4.52 Satisfaction scores among groups with different periods of residence in the region

	<10 yrs		10-20 yrs		>20 yrs		Significance
Domains	Mean	Std Error	Mean	Std Error	Mean	Std Error	
Economic	3.42	.08	3.42	.07	3.29	.03	
Social	3.72	.08	3.65	.06	3.65	.02	
Political	3.52	.08	3.48	.06	3.52	.03	
Environmental	3.44	.11	3.65	.09	3.56	.03	
Biomedical	3.69	.07	3.78	.08	3.51	.03	P<0.05
Spiritual	4.22	.08	4.24	.08	4.15	.03	
Overall	3.67	.05	3.70	.04	3.61	.02	

There is a statistically significant difference in the satisfaction levels in the biomedical domain between groups with different residence periods in the mining region.

Mining and non-mining comparison

There is a statistically significant difference only in the satisfaction levels in the environmental domain between the mining and the non-mining regions. Otherwise, people in mining and non-mining villages are equally satisfied with their lot (Table 4.53).

Table 4.53 Satisfaction levels across mining and non-mining villages

	Mining		Non-mining		Significance
Domains	Mean	Std Error	Mean	Std Error	
Economic	3.32	.03	3.35	.07	
Social	3.66	.02	3.71	.07	
Political	3.52	.02	3.50	.05	
Environmental	3.56	.03	4.18	.06	P<0.05
Biomedical	3.56	.02	3.46	.06	
Spiritual	4.17	.03	4.28	.07	

Comparison between objective and subjective measures

In the table below we compare the subjective with objective measures and find that despite lower objective measures, there seems to be a much higher level of satisfaction with these conditions than expected. This in a way, supports those that suggest that people adjust to conditions and indicate higher satisfaction levels than conditions warrant. Thus we see that while there is a difference of

0.14 in overall scores of objectives measures across mining and non-mining regions, the difference in overall satisfaction levels is only .02.

Table 4.54 Objective and subjective: A comparison

	Mining		Non-mining	
Domains	Objective	Subjective	Objective	Subjective
Economic	0.49	0.66	0.7	0.67
Social	0.54	0.73	0.51	0.74
Political	0.53	0.7	0.44	0.7
Biophysical	0.32	0.71	0.84	0.84
Biomedical	0.47	0.71	0.45	0.69
Spiritual	0.67	0.83	0.71	0.86
Overall	0.5	0.73	0.61	0.75

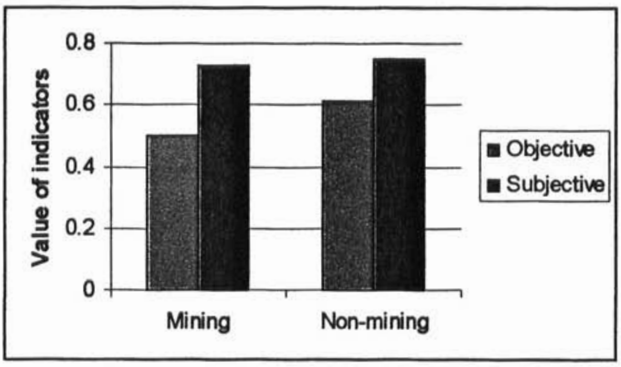


Figure 4.5 Objective and subjective indicators in mining and non-mining regions

Across clusters

Table 4.55 Objective and subjective measures across clusters

Domains	Cluster I		Cluster II		Cluster III	
	Objective	Subjective	Objective	Subjective	Objective	Subjective
Economic	0.65	0.67	0.58	0.64	0.11	0.69
Social	0.69	0.75	0.49	0.73	0.49	0.72
Political	0.67	0.71	0.53	0.69	0.35	0.73
Biophysical	0.66	0.78	0.14	0.68	0.27	0.7
Biomedical	0.68	0.73	0.42	0.71	0.36	0.69
Spiritual	0.82	0.88	0.58	0.82	0.69	0.81
Overall	0.7	0.75	0.46	0.71	0.38	0.72

While objective and subjective scores are close in cluster I, the differences are significant between clusters II and III; the difference being greater in cluster III than in cluster II. In general, the subjective measures do not differ much, but the objective do.

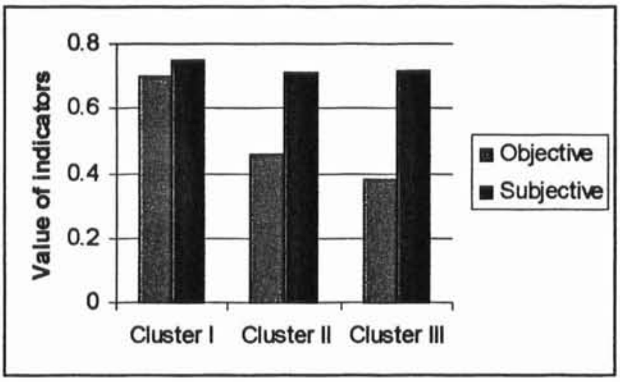


Figure 4.6 Objective and subjective indicators across the three clusters

By gender: mining and non-mining

A similar observation can be made with regard to the comparison across gender.

Not much difference exists across subjective scores for males and females in both mining and non-mining villages, but major differences are observed in objective scores.

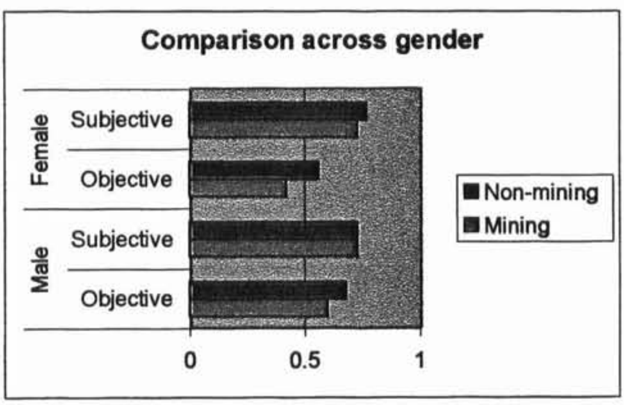


Figure 4.7 Objective and subjective indicators across gender

Conclusions

This chapter sought to develop a tool to measure the quality of life of people in mining regions. This was defined as the 'the satisfaction of a person with the conditions in the domains of life of importance to him/her'. The QOL tool evolved through the use of focus groups and researcher inputs. The tool was revised based on feedback obtained from the piloting exercise and team inputs. Three different versions of the QOL tool have now been developed.

The main differences in features across the three versions are given in Table 4.56 below.

Table 4.56 Differences across the versions of the QOL tool

Particulars	Version I	Version II	Version III
1 Type	Fully subjective 100 %	Objective: Subjective 50:50	Objective: Subjective 75:25
2 Type of questions	Fully structured closed ended questions	Semi-structured with both closed-and open-ended questions	Semi-structured with both closed-and open-ended questions
3 Information	Only subjective, no objective	Covers objective as well as subjective (better coverage of both)	Subjective information is less
4 Time required	45 minutes	1 hour	30 minutes
5 Interviewers view about canvassing	Moderate	Difficult	Easy
6 Data entry and computation	Easy direct	Not so direct	Not so direct
7 Advisable method of collection	Direct filling by respondents	Direct filling by respondents	Interviews/direct filling by respondents

All three versions were tested and found reliable for internal consistency. We believe that all three versions have potential for use depending on the economic and social context of the mining region. Version I will be of importance in a developed country, as some basic conditions are already met; Version II would be more appropriate for developing regions where there is a certain degree of political and social emancipation; Version III would be more appropriate for developing regions, where political and social development is more constrained as the responses with regard to levels of satisfaction are less demanding, but the need to measure objective conditions is very important.

In the testing of Version III, while there is a difference in objective conditions between mining and non-mining regions, there is no statistically significant difference in satisfaction levels between mining and non-mining regions except for the environmental domain where the people in the mining region report lower satisfaction levels in all facets. This difference between levels of satisfaction levels and objective conditions is especially of importance in the case of women, who report higher satisfaction levels but have an overall lower access to resources and other objective conditions, thus supporting the views of Sen and Nussbaum which suggest that QOL assessments should not seek to capture just satisfaction levels as these do not reflect real choices in developing countries.

5 Impact accounts for the mineral sector in Goa–an exploratory exercise

Introduction

The third tool in our conceptual framework is one to track sustainability in a mining region by accounting for environmental and social impact. These impacts are valued and the information is used to adjust the income obtained from mining to reflect the true income. The difference between the environmental-and social impact-adjusted income for the region and the value added to GDP by mining from the region is an indicator of the social and environmental changes in the region. The adjusted income over time can serve as a sustainability marker.

It is important to state here that the valuation attempted is based on impacts identified in the TERI 1997 and other secondary data. No new surveys or primary data collection have been done to arrive at more precise estimates of value, the objective being to demonstrate how the tool can be of use. More detailed studies are required to enable improved estimates of the value of these impacts.

The framework that can be used for the monetary valuation of the environmental impact due to the mining activity is shown in Figure 5.1. The valuation that follows differs slightly from this in that it makes simplifying assumptions and uses more simple methods than suggested in the figure.

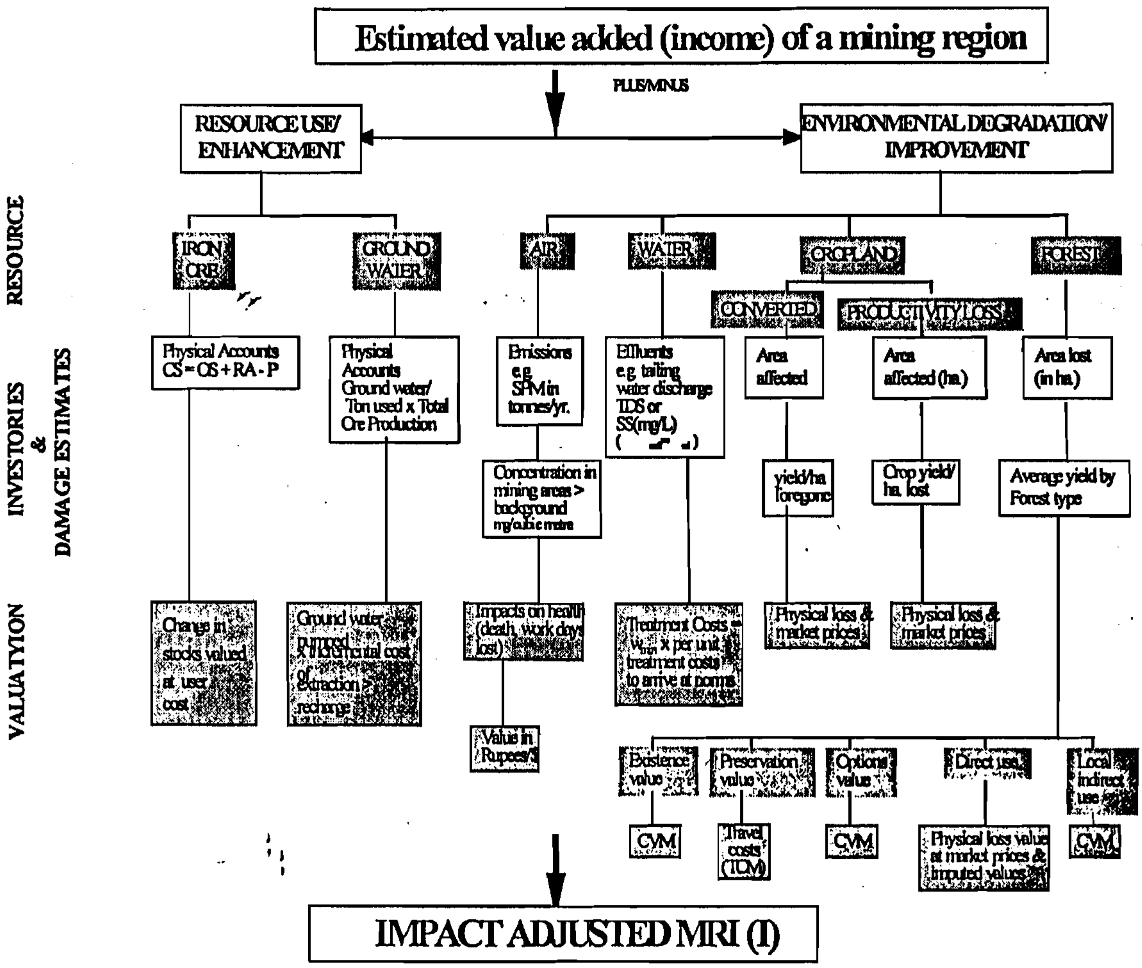


Figure 5.1 A framework for environmental and resource impact accounting

This chapter has two sections. Section I reviews the literature on the subject and Section II values the impacts.

Section I: Review of the literature

Sustainability issues in mining

An important aspect of the developed framework is that it reflects sustainability. Thus, the goal of improved well-being applies to present and future generations. Many definitions of sustainability are found in the literature[1], but the most appealing one is that of Solow (1992) where he refers to sustainability as the passing on to future generations of a generalized capacity to produce well-being (p. 14). One way to achieve this is to be attentive to society's capital stocks. Pearce and Atkinson (1995) discuss the Hicks-Page-Hartwick-Solow (HPHS) rule in which the condition to achieve sustainability is that the value of net change in capital stock (K) be equal to or greater than zero (p. 167-168).

Capital assets have traditionally been taken as having 3 forms: man-made capital, K_M; human capital or the stock of knowledge and skills, K_H, and natural capital, which includes both natural resources as well as environmental resources which provide ecosystem services, K_N. However, closely related to the notion of human capital is social capital, which has been defined as 'features of social organization, such as networks, norms and social trust that facilitate coordination and cooperation for mutual benefit', which can be denoted as Ks (Putnam 1995:67. See also Coleman 1988). Social capital thus refers to those stocks of society's resources that comprise relationships among persons, social trust, norms and networks that are productive as people can draw upon them to solve common problems.

Minerals development can have the following impact on the underlying capital stock. It can:

- Use up or create new reproducible man-made capital (denoted by K_M).
- Use up through depletion or enhance through new discovery the stock of mineral resources (K_{N1});
- Degrade or improve the environment (K_{N2});
- Develop, be neutral, or actually reduce the stock of knowledge and skills (K_H). This can happen if the proceeds from mining are used to develop human capability; neutral if minerals development does nothing towards this and be negative if it actually reduces the pool of indigenous knowledge by impinging on and changing traditional skills and lifestyles.

[1] See Pezzy, 1993 for a review of some of these definitions.

- Create new or destroy relations among various stakeholders (K_S). This may be especially so in connection with relations within local communities, or the development of a new civic environmentalism which the activity may generate locally.

The literature distinguishes between two types of sustainability rules: the weak and the strong.

The weak sustainability rule

If capital stock is assumed as taking 3 forms: man-made, human and natural, and it is further assumed that human capital does not depreciate, then the weak sustainability indicator is of the form: (Pearce and Atkinson 1995)

$$Z = \frac{S}{Y} - \frac{\partial_M K_M}{Y} - \frac{\partial_N K_N}{Y} \qquad (1)$$

where

Y = gross income

$\partial_M K_M$ = depreciation on man made capital stock

$\partial_N K_N$ = depreciation of the natural capital stock, both depletion and degradation

S = gross savings

Z = sustainability index.

If this sustainability indicator is used at the level of a mining region then it can be said that mining contributes to sustainable development if Z is > or = 0. This approach is complementary to environmentally-adjusted net income accounts (Pearce and Atkinson, p. 171). Imputed values for changes in natural and man made capital are subtracted from GDP to arrive at adjusted accounts.

The sustainability marker for the mining region being developed in this study draws on this. This is the impact adjusted-mining income of the region (I_m).

Impact adjusted mining income of region (I_m)
= Valued added to GDP by mining in the region (Y_m)
+/- value of mineral resource depletion/enhancement ($V_{md}/_{me}$)
+/- value of environmental degradation/improvement attributed to mining ($V_{ed}/_{ei}$)
+/- value of social impacts attributed to mining (V_{SI})

That is $I_m = Y_m +/- V_{md}/_{me} +/- V_{ed}/_{ei} +/- V_{SI}$

Mining contributes to sustainable development if $I_m \geq 0$. The weak sustainability rule assumes substitution possibilities among the various components of capital. As Pearce and Atkinson argue this is then consistent with running down one form of capital, say natural capital, as long as the proceeds are reinvested as per the HPHS rule. This is possible in the case of mineral resources as long as part of the rents from mining are reinvested into reproducible capital or human capital and not consumed.

The strong sustainability rule

There are, however, some aspects of natural capital that cannot be substituted, so that no trade-off is possible. For that component termed in the literature as 'critical', no depreciation can be allowed. In the case of natural capital, there are certain aspects which provide life-supporting functions for which there can be no substitution. Hence there is need to identify which of the components of natural capital are critical and which are non-critical to the functioning and well-being of that region. The remaining components of natural capital can be assumed to be substitutable. Pearce and Atkinson suggest that the 'critical' natural capital be identified, and be constrained to be non-decreasing under an alternative strong sustainability rule.

We suggest that this argument of criticality can be extended to the other 2 forms of capital—human and social. In the case of human capital, there is need to identify what part of the stock of human capital is vulnerable to mining activities and whether this stock can be allowed to depreciate due to mining. Where is the trade-off possible? If, for example, mining is going to be located in a region, which causes the movement of a people who had a particular lifestyle that used certain skills and practices, and if resettling them causes a loss of that lifestyle and the subsequent deterioration of the skills that supported that lifestyle, then there is need to know if this is acceptable or not. A case for treating such capital as critical can be made on 2 grounds: First, uncertainty and lack of information about indigenous cultures and other world views. There may be skills and practices there that have value to human kind as a whole[2]. As in the case of the environment, where there are threats of serious or irreversible damage, lack of knowledge should be used as a reason to act conservatively. Second, the uniqueness of cultures and other arguments used for conserving bio-diversity

[2] We can take as examples the increasing importance of herbal medicines, cosmetics, the use of acupuncture, ayurveda, despite all the scientific advances in allopathy.

(Randall 1991)[3]. The strong sustainability rule needs to be extended to include human and productive social capital[4]. Since it is not as yet possible to value these changes in human and social capital that can be attributed to mining, they need to be monitored using special indicators and the rule made to apply to them.

Accounting and valuing for environmental and social impacts

In this chapter, impacts of mining are valued monetarily. The impacts that were identified in the TERI 1997 study were: air and water pollution, loss of forests, groundwater depletion, mineral resource use and reduced agricultural productivity. This section summarizes some of the literature on approaches and methods that can be used in the valuation of such impacts.

Health costs

Valuing the impacts of lowered air and water quality on the health of those exposed is one way to arrive either at a value for air and water pollution; it can also be treated as a health-related social cost. In either case, the first step in valuing health costs is estimating the physical impact through cause-effect functions. The cause-effect functions relate information on changes in the ambient environmental quality for different pollutants to different health outcomes also referred to as health endpoints. The principle is that changes in ambient levels of certain pollutants can be statistically related to observed changes in sickness/illness and premature deaths in a population. Through regression analysis, coefficients are estimated that are then multiplied by changes in pollutant concentrations and the population exposed.

In general, the estimated health outcome is estimated by the following relationship:

$\Delta H_i = b_i * POP_i * \Delta A$

Where

ΔH_i = change in population risk of health outcome i.

b_i = slope from the cause-effect function for health outcome i.

POP_i = population at risk to health impact i.

ΔA = change in annual ambient pollutant concentration.

---

[3] The principle of supporting all forms of diversity in life is recognized in several of the documents of the Canadian government. See for example, Government of Canada, 1990, which in its Report of the Interdepartmental Workshop on Sustainable Development in Federal Natural Resource Departments, calls for the preservation of ecologic, social and economic diversity.

[4] Social capital is not always productive; it can have a downside. See, Portes and Landolt 1996.

POP_i refers to the entire population of a defined area – for example, a city, or a population in a particular age group, which is particularly vulnerable.

Substantial evidence of a strong correlation between exposures to ambient air pollution and health risks has been gathered in developed countries, and for some developing countries as well (Working Group on Public Health Outcome). These are: (1) clinical studies based on human volunteers in controlled experiments; (2) toxological studies, in which effects on animals are extrapolated to humans in risk-assessment studies; and (3) epidemiological studies that examine how the incidence of health outcomes vary with the ambient concentration of a particular air pollutant. Of these studies, the epidemiological studies are thought to provide the most reliable measure of health effects under normal human exposure conditions. Most epidemiological studies are either cross-sectional or time-series studies. Time-series studies typically correlate the daily variation in mortality and morbidity with pollutant concentrations over a particular period, and hence primarily measure acute exposure to pollution. Cross-sectional analysis on the other hand, compares differences in health outcomes across several locations at a selected point in time. In principle, this captures both the acute and chronic impacts of exposure (Cropper et al 1997; Ostro 1994).

The next step is to value the physical impact of the disease in terms of loss of earnings which individuals suffer as a result of environmental factors, plus the resource costs of medical treatment and health care.

Mortality

There are two approaches, which are generally used to value premature mortality: (1) The Human Capital approach–which values an individual's life according to the net present value of his productivity; and (2) WTP/WTA-based methods – which measure the value which society places on an individual distinct from his wage-earning capacity.

The logic underpinning the Human Capital approach is explained as follows: If one is living and healthy, economic value of his/her life to society is expressed in terms of the output they generate from working. The value of their labour, i.e. the wage they earn, is assumed to be representative of the value of their working time. Based on this, the Human Capital approach assumes that over one's entire life the discounted expected value of his future wage stream constitutes the minimum value society attaches to his life at that moment.

Hence, in case of premature death, society will lose the value of his output. It then follows that, if one dies prematurely, the minimum cost imposed on society is represented by the present value of his projected earnings foregone. The Human Capital approach thus considers humans as units of capital that produce goods and services for the country.

Brandon (1995) in his study has estimated the value of life in India using the Human Capital approach. The assumptions included: wage level in 1992, 5% real interest rate, 10 years additional life span, USEPA statistical value of life arrived at by Contingent Valuation and Hedonic Wage studies and applied to the Indian context by applying the ratio of India/USA per capita incomes. The net present value estimate is Rs 156 million per death, which is the lower estimate and the US-EPA estimate is Rs 1,470 million per death, which is the higher estimate[5].

Morbidity

Morbidity is often valued through the cost-of-illness approach. The cost-of-illness is the name economists give to the resource/opportunity cost-based approach to estimating morbidity. As the name implies, the cost of illness is measured as the sum of:

The direct out-of-pocket expenses due to sickness (e.g. medicine, doctor and hospital bills)

+

any associated opportunity costs (e.g. loss of earnings resulting from the illness)

There are advantages with the cost-of-illness approach, in that the necessary data is relatively easy to obtain, and secondly, the estimates can be effectively communicated, since these are based on costs, which people understand. In addition, the primary data on duration of illness can be obtained from health centres, hospitals or the department of health, while data on the treatment costs can be got from the local private and public hospitals. With respect to the treatment costs, they have been extrapolated for use in studies in other countries by adjusting them downward by a factor equal to the average daily wages.

Issues in valuation

The basic step in the valuation of the physical aspect (primarily in health-related costs of air pollution) as with most of the studies summarized in the table below is

[5] These figures are from Brandon converted into Indian currency using 1996/97 exchange rate of US $ = Rs. 37

the use of dose-response functions. However, dose-response functions have been estimated largely for developed countries and for studies involving developing countries, one has to rely on the dose-response functions estimated for developed countries. This raises the question of whether the cause-effect functions can be transferred to developing countries. For many health impact assessments in developing countries, there have been no epidemiological studies. As a result, one is left with no other option but to use the results from such studies in industrialized countries. However, there are a number of assumptions, which need to-be made before the results are applied to developing countries, which can be difficult to defend:

- Baseline health status is the same in industrialized and developing countries. People in developing countries may be more susceptible to adverse health outcomes due to poorer living standards, thus it may be right to assume that the general level of health is worse. Therefore, the dose-response function for a city like Mumbai will be much steeper than it is for a city like Singapore. It is difficult, however, to assess whether the dose-response functions will indeed be steeper unless they have been estimated specifically in that country.
- Distribution of causes of death is the same as industrialized countries. Most epidemiological studies look at the impact of a change in air pollution on the percentage change in total deaths or total cases of a particular morbidity outcome. Hence, to take a cause-effect function from say City X and apply it to City Y, one must know the baseline number of cases of health endpoints and not just the total population. By expressing the cause-effect coefficients on a per-person basis, the baseline number of cases in City X into the analysis is implicitly incorporated. Given the above, the estimated health outcomes in City Y will be under/over-estimated to the extent that the baseline health outcomes differ from City X.
- Levels and duration of exposure. The levels and durations of exposure are assumed to be the same as in developed countries. However, in developing countries, people spend more time outside or in buildings that are not air-conditioned. They are exposed to pollutants for a longer duration. This is exacerbated by the fact that ambient concentrations are much higher than in developed countries. As a result, both factors, when combined lead to an underestimate if the dose-response functions are transferred.

Despite all this, however, dose-response functions estimated for developing countries such as Chile and India have been shown to correspond well with those from the developed or the industrialized countries (see Cropper et al 1997 and Ostro et al 1996).

Valuation of the health impact due to water pollution on the other hand, is a far more complex issue. This is because, it is much easier to make assumptions about the exposure of a population to polluted air than exposure to polluted water since there are many more options concerning water treatment and consumption than there are for air. In 1993, the World Bank and the World Health Organization developed the concept of DALY, 'Disability Adjusted Life Years'. DALY is a measure of the burden of the disease and it reflects the total amount of healthy life lost. In other words, DALY is a measure of the status of health of a population and is also a measure by which to judge which interventions to improve the health service deserve the highest priority. DALY are calculated as follows: For mortality impacts, years of life lost are defined as the difference between life expectancy in a developed country population and the actual age at death due to the disease at birth. Each year of life lost is assigned a relative value. The relative values rise from zero at birth, peak at age 25 and decline thereafter. The years of life lost thus are discounted (using a 3 percent discount rate) and summed to determine the number of DALYs lost due to premature death. The procedure is similar for morbidity impacts, with the principal differences being the calculations that involve the estimated duration of disease, which may be measured in 'days' instead of years and 'severity weights' for converting the time spent ill or disabled, to equivalent years lost. Severity weights range from 0 to 1 and reflect the relative impact of a disease on a person's ability to carry out normal activities. The shape of the relationship between different values of a year of life and age and the factors that are considered in determining the severity weights indicate that DALYs strongly reflect foregone current and future earnings.

Though, the DALY method would be ideal to estimate the costs of water pollution, it is extremely data intensive requiring data on variables such as the average age of the onset of disability, the age at which the death occurs, the proportion of the disease incidence leading to a disabling outcome, which makes the methodology often unfeasible to use.

Table 5.1 gives a summary of the important studies on the valuation of health costs.

Table 5.1 Summary of important studies on the valuation of health costs

Cost	Value	Location	Methodology	Source
Water Pollution	The cost of water pollution is estimated to be Rs 24, 827 per 100 people in 1981 prices.	India	Cost-of-illness approach and cost-of-treatment approach	Verma (1990)
Air Pollution	Value of life is 40,018 $ (higher estimate) and 4,217$ (Lower estimate) due to air pollution	India	Human Capital approach and US-EPA; Ostro's dose-response functions; DALY	Brandon (1995)
Water Pollution	30.5 million DALYs lost each year due to water pollution			
Air Pollution	A 10 microgram per cubic meter increase in PM_{10} is associated with a 1.1% increase in mortality.	Santiago, Chile	Dose-response function	Ostro (1995)
Water Pollution	9% of the deaths and 9.5% of total disability adjusted life time years is due to water pollution.	India	DALY	Murray and Lopez (1996)
Air Pollution	Impact of non-trauma deaths in Delhi is less than in the US	New Delhi, India	Econometric techniques, Dose-response functions	Cropper et al. (1997)
Air Pollution	The respiratory diseases among children is significantly affected by air pollution measured as PM_{10}	Santiago, Chile	Dose-response functions	Ostro (1998)
Air Pollution	Statistical value of life is estimated in the range of 6.4-million - 15 million Rs at 1990 prices.	India	Compensating wage Differential approach	Simon (1999)
Air Pollution	Annual particulate-related mortality risks are estimated to be in the range of 960–2667 additional deaths per year.	Volvograd, Russia	Health Risk Assessment, Cost-Benefit Analysis	Larsen et al. (1999)
Air Pollution	Mortality is estimated to be in the range of US $73-950.	Brazil	Transfer Pricing, Hedonic Pricing and Output Foregone Pricing	Ronaldo (2000)
Air Pollution	Cost of missing work exceeds cost of seeking relief by 1.61-2.26 times	USA	Cost of illness approach and Willingness to pay	Alberini (2000)
Air Pollution	The damage costs related to health effects of electricity generation are relatively small, but not negligible, ranging from 0.006 US cent to US 0.05 cent per kilowatt-hour.	Thailand	Pathway Approach	Thanh and Lafavre (2000)

Loss of forests

Forests have both direct and indirect benefits to society. The direct economic benefits are through the generation of marketable products while the indirect benefits are through watershed protection, environmental stability, and other services. Forests are major sources of certain production stocks such as timber, firewood, and medicinal plants and also help in soil protection, water retention and nutrient recycles.

Since forests are capital assets, they depreciate due to use and consumption. Therefore, it is vital to clearly define the corresponding depreciation of the asset in both physical and economic terms. Though environmental valuation was attempted as early as 1978, the attempts at valuation of forests began much later. Solorzano et al. (1991) attempted to value the natural resource depletion in Costa Rica; Munasinghe, McNeely (1984) discuss a number of cases in the protected areas around the world; and Brandon, Honmann and Kishor (1995) consider the loss in industrial fuelwood due to deforestation in India.

The classification (as per Figure 5.2) facilitates the choice of methods for valuation. While market valuation may be possible for some use-values such as timber and NTFPs, various non-market techniques have to be employed for the valuation of other benefits.

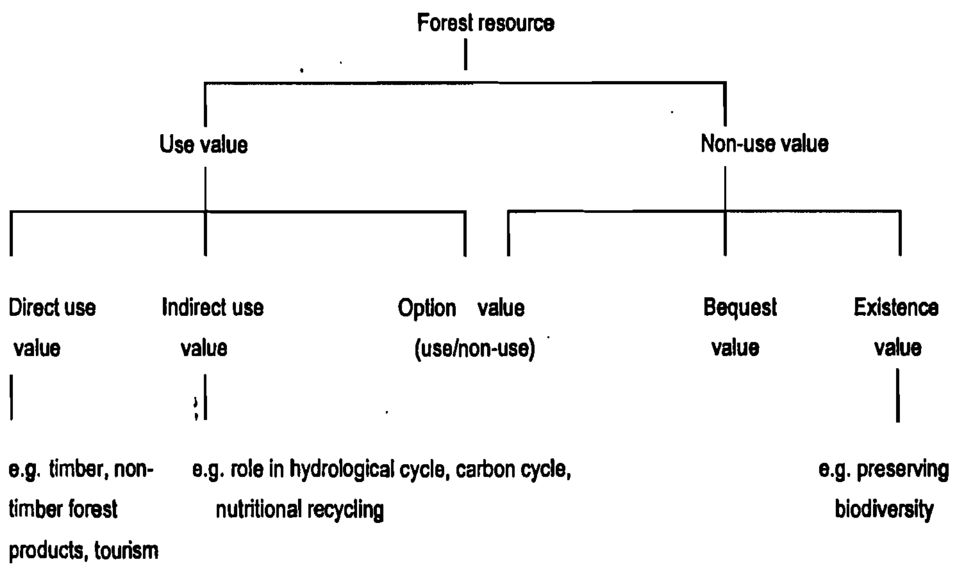


Figure 5.2 Role of forests
Source. Adapted from Bateman and Turner (1993) as cited in Chopra and Kadekodi, 1997

Issues in valuation

Estimation of use and non-use values are based on such methods such as travel cost, contingent valuation, change in productivity and replacement approach. Table 5.2 provides a summary of the methods of some studies that have estimated the value of services provided by forests.

Numerous studies have captured both the tangible and the intangible benefits provided by forests. However, though the valuation of the tangible benefits is a relatively straightforward task, valuation of ecological functions on the other hand is a complex task due to gaps in the data and knowledge. The complexity arises due to interaction between anthropogenic activities, changes in vegetation and atmospheric dynamics. The inflection points beyond which the discontinuities in the ecological system begin to show up, that is, the level beyond which the forests are not able to absorb the stress, need to be researched. Until the time these gaps are filled, resource accounting will have to be confined to incorporating the main use values of forests. Though the estimation of ecological or environmental services is ridden by uncertainty, yet it is imperative that any study that attempts to estimate the value of forests captures both the tangible and the intangible benefits.

Table 5.2 Summary of important studies on the valuation of forests

Benefit	Annual value	Location	Methodology used	Source
Direct and indirect use values and non-use values	The use value is estimated to be Rs 13, 970 crores while the non-use value is estimated to be Rs 65,580 crores.	India	Surrogate Market Techniques	Lal (1989)
Recreation	Recreation is valued at 39.7 million dollars	Galapagos Islands, Ecuador	Hedonic Pricing	Edwards (1991)
Recreation	NPV of Recreation is 12.5 million US$.	Costa Rica	Travel Cost Method	Tobias and Mendehlson (1991)
Total economic value	The total economic value is 4 billion US$	Mexico	Damage cost, mitigation cost, contingent valuation etc	Pearce (1993)
Watershed values	Rs 2.0 lakh per hectare metre of soil	Yamuna Basin	Indirect method (Reduced cost of alternative technology)	Chopra and Kadekodi (1997)
Ecological functions for local residents (use value)	Rs 624 per hectare	Yamuna Basin	Contingent valuation method	Chopra and Kadekodi (1997)
Direct use	Annual loss due to foregone timber is 45 billion US$ while the annual loss due to foregone fuel wood is 12 billion US$.	India	Net market price	Mitra (1998)
Eco-tourism /Recreation	Rs 427.04 per Indian visitor and Rs 432.04 per foreign visitor	Keoladeo National Park, Bharatpur	Travel Cost	Chopra K (1998)
Eco-tourism	Rs 2.95 million (Rs 34.68 per visitor)	Kalakadu Mundanthurai Tiger Reserve	Contingent Valuation Method	Manoharan and Dutt (1999)

Continued

Table 5.2 continued

Benefit	Annual value	Location	Methodology used	Source
Carbon Store	Rs 1.292 billion (total forests) and Rs 20125 per ha	Indian Forests	Species-wise forest inventory data	Haripriya and Parikh (1999)
Soil conservation	Cost of soil erosion: Rs 21583 per ha	Doon Valley	Replacement Cost Approach	Kumar P (2000)
Total Economic Value	The total estimated loss of economic values is 1175$ per hectare.	Amazonian Forests	Green accounting and Total Economic Value Approaches	Torras (2000)

Losses due to groundwater depletion

Groundwater is a renewable resource, and the stock of this resource is dependent on the annual extraction and the recharge. Recharge is from rain and other sources such as seepage through canals and flow through aquifers. Groundwater depletion occurs when there is insufficient recharge to match the extraction. There are several sources of groundwater. The process by which groundwater depletion takes place directly due to mining is when there is need to dewater the pit to allow mining below groundwater level. If the aquifers are connected, extraction of groundwater is a threat to other uses of water such as agriculture, industry, and the domestic sector.

Issues in valuation

The estimation of the value of groundwater loss involves three basic steps: 1) Estimating the water pumped out annually 2) Assessment of the amount of water for aquifer recharge and 3) Cost of reinjecting water into the aquifer. The loss is then valued as:

Amount of water pumped out* marginal cost of reinjecting water into the aquifer.

While the estimation of water pumped out and the cost of reinjection of water into the aquifer may not pose much of a problem, the assessment of the aquifer recharge is one of the most important and difficult steps in the valuation of groundwater depletion. There are several methods that can be used for the assessment of aquifer recharge and these are: Sequential Water Balances approach, Tritium Balance approach etc. However, these methods are extremely data intensive requiring data on discharge by type, precipitation, evapotranspiration etc., which may not be easy to come by. In absence of data on these variables, one may have to rely on surrogate market techniques to value the loss of groundwater.

Acutt (1998) presents a review and assessment of how groundwater resources are developed and utilized in Metro Manila. It adopts water balance models as well as Long-Run Marginal Cost methodologies in calculating the groundwater potential and cost of groundwater pumping. Through these methodologies, the study attempts to incorporate environmental externalities in valuing the unit cost of groundwater extraction. It then identifies the need to refine the methodology and data set for instituting both supply and demand relationships and projections.

Ahluwalia et al. (1998) have focussed on the value of groundwater depletion and degradation in India. The study estimates the future costs of groundwater depletion in a few critical districts in Haryana and across the country, using results from the more detailed estimation for the districts in Haryana. The study also estimates the costs of extending the supply of drinking water and sanitation facilities and of improving the quality of water. According to the study, the future annual incremental costs of extraction of replenishable groundwater depletion in Haryana is in the range of Rs 66-69 million and is in the range of Rs 4.9—9.8 billion per year in the over-exploited blocks across India. The estimates of incremental costs of supplying water and of ensuring drinking water security on the other hand are Rs 22.5 billion and Rs 121.6 billion, respectively.

Landgreen (1999) has attempted to estimate the value of water by determining net economic contribution of groundwater in the agricultural sector, which is then compared to the use values in other sectors. The study then discusses efficiency in resource allocation of water and the possible measures to create efficiency in the allocation of water. It finally determines the value of water using various valuation techniques.

Thomas (1999) has discussed in detail the valuation of costs and benefits of water use. The study explains in detail the methodologies for valuing the benefits and costs of water pollution abatement. It discusses methodologies such as the damage avoidance approach and the health approach to value the benefits while treatment costs, reducing inputs, taxes on pollution generation activities and land use controls are cost valuation methodologies discussed in the study.

Burke et al. (2001) give an exhaustive account of the principles and practices of groundwater management. The book begins with a review of the important role of groundwater in society, for economic development, food security, domestic and commercial water supplies and sustaining the environment. It explores the increased competition for groundwater among users and between sectors. The study then focuses on guidelines for addressing groundwater depletion and degradation one of which is the choice of spatial scale and identification of stakeholders for groundwater management, and discusses implementation of policies from various starting points accounting for local factors. It is apparent that not enough study on the valuation of groundwater depletion has been done in India.

Losses due to mineral depletion

Mineral depletion is the depletion in the reserves of an exhaustible resource due to the extraction and production of the ore. The identified reserves refer to mineral-bearing ores whose location, quality and quantity is already known while undiscovered reserves refer to unspecified bodies of mineral-bearing material surmized to the extent possibly on the basis of the broad geological category. Identified ores may not be economically or legally feasible to extract. The size of the resource that is considered economical and therefore recoverable depends upon investment and extraction costs and prices including the price of substitutes. The assumption of fixed and non-renewable stock reserves is thus considered to be limiting in the determination of the size of a nation's resource base. An accounting structure needs to keep a systematic track of the exploitation of the mineral resource that is taking place through physical and monetary accounting. Physical accounting of resources provides a measure of resource availability both in the short and the medium term. It explains the trend in the remaining reserve base, from which extraction and the income are derived.

Monetary valuation of the depleted resources, on the other hand, gives an idea of the depleting wealth of the region. This use of mineral resources can be valued using the Present Value method, the Net Price method or the User Cost method.

Present Value method

The present value V_0 of a natural resource is the sum of the expected net revenue flows N_tQ_t, discounted at nominal or real interest rates r for the life T of the asset; where N_t is defined as the total unit value of the resource less the costs of extraction, development, exploration and Q_t is the quantity exploited during the period t.

Net Price method

The value of the resource at the beginning of period t, V_t, is the volume of the resource R_t multiplied by the difference between the average market value of the resource p_t and the per-unit (marginal) cost of extraction, development and exploration, including a normal return to capital, c_t.

User Cost method

This method (El Sarafy 1989) splits the total resource rent (R1) into its capital components (R-XT), which need to be reinvested to ensure a perpetual stream of income from the resource and its true income (X) component which can be consumed; r is the rate of return and T is the number of years in which extraction can take place at the current rate.

The user cost method is based on the following formula:

$R - X = R/(1+r)^{T+1}$ where

R = p-c =unit value of the resource less the costs of extraction, development and exploration, assumed to be constant over its lifetime (of T years)

X = annual income in perpetuity

r= rate of discount

T = lifetime of the resource.

X is the 'true income' element calculated so that R-X represents a capital element whose accumulated investment at an interest rate r during the n years would create a permanent stream of income of X. The Net Price method gives an upper bound and the User Cost a lower bound estimate of the value of depletion of mineral resources.

Social costs due to impact on agricultural land

Mining creates social costs in terms of loss of agricultural livelihoods when cropland is diverted to mining and also when there is a loss of productivity. Cropland productivity loss is the outcome associated with the degradation of soil, either due to silting or due to desiccation. Soil degradation has been defined as a process that leads to a decline in the soil's current and/or future capacity for productivity as a result of human activity. Degradation may be physical or chemical. It is a complex phenomenon driven by strong interactions between natural and socio-economic factors.

In order to estimate the economic impact of degradation due to depletion of soil nutrients, tons of soil lost per hectare per year may be assumed to be the opportunity cost of degradation due to depletion of nutrients. Crop yields are not only a function of soil fertility. And, physical soil loss is only a rough estimate of declining fertility. However, in a case where other variables can be controlled, the loss of topsoil is an accepted indicator of the loss in crop yield. There have been quite a few empirical studies done in the field of yield reduction due to soil degradation. There are several econometric models, which require the effect of soil loss on crops under continuous cultivation. The models developed by the

International Institute of Tropical Agriculture (IITA) consist of a simple exponential relation:

$$Y = C_e^{-\beta x}$$

where

Y = yield in tonnes per hectare

C = yield on unaffected land

β = coefficient varying with crop and slope

x = soil loss in tonnes per hectare

Alternatively, the following equation is also used to calculate the percentage change in yield for every level of soil loss: $Y = 1 - e^{-\beta x}$

Table 5.3 summarizes the key studies on the valuation of cost due to the impact on agricultural land.

Table 5.3 A summary of the key studies on effect of soil degradation on agricultural lands

Cost	Annual Value	Location	Methodology used	Source
Soil Erosion	1.5 billion $(US)	Zimbabwe	Replacement Cost Method	Stocking (1986)
Soil Erosion	9.4 billion $(US)	Philippines	Net Market Price	Cruz etal (1988)
Soil Erosion	US$ 25.6 million - 91.2 million was the estimated off-site cost and $ 315 million was the estimated on-site costs.	Java	Yield Reduction Approach	Magarth and Arens (1989)
Soil Erosion	US$ 0.7 - 2.1 million in 1988-89 prices.	Zimbabwe	Yield Erosion Models	Grohs (1992)
Soil Erosion	$ 59per hectare	Mali	Replacement Cost Approach	Van der Pol (1992)
Soil Erosion	The estimated amount of degradation was 88-188 hectares.	India	Productivity Approach	Abrol and Sehgal (1994)
Soil Erosion	The estimated on-site impact was in the range of Rs 52-84 billion	India	Yield Reduction Approach	Brandon (1995)
Soil Erosion	The estimated loss is in the range 116,212,000 K to 164,818,000 K	Malawi	Regression techniques; Productivity Approach.	Bishop (1995)
Soil Erosion	The estimated loss was in the range of Rs 89 billion-232 billion	India	Yield Reduction Approach	Narain and Girisha (1998)

The estimation of yield reduction factors is the most essential element of the valuation of loss of crop productivity due to soil erosion. One needs data on the loss of topsoil (in tonnes per hectare) in order to estimate the yield reduction factor, which may vary from crop to crop. In the absence of this data, one might have to rely on secondary sources for the yield reduction factors. However, these figures could be purely hypothetical and might not reflect the actual extent of degradation in an area, which is a major limitation. Personal interaction with the farmers to get an estimate of the yield reduction factor might be the only practical way to overcome the limitations imposed by the data.

The choice of discount factor

The question of the choice of proper discount rate is one that often comes up in policy and project appraisal decisions. The relationship between the environment and the discount rate is not a simple one. The issue is complex, primarily since the issue of intergenerational equity is involved here.

There are broadly two discount rates that are available: the consumption rate of interest and the opportunity cost of capital. An alternative to the discount rate is provided by the accounting rate of return, which is basically preferred for use in project appraisals. The accounting rate of return is a weighted average of the other two rates of return with the weights depending upon how much of the government's income is allocated to investment.

The social discount rate for this part of the study was calculated using the standard formula for discounting future consumption (Pearce 1991).

$S = Ce + p$

C = rate of growth of per capita real consumption

e = elasticity of marginal utility of consumption

P = rate of pure time preference

A common assumption in empirical work is that of the constant elasticity of marginal utility of consumption to be 2; on ethical grounds, we take the position that there can be no discounting of utility over time periods, so time preference rate is zero. Rate of growth of per capita real consumption in India over the period 1980—96 was 2.3% (World Development Report 1998/99). Taking the past growth rate as guide, C is set at 2.3% and S works out to 4.6%, or 5%.

The moot question when it comes to environmental issues and particularly natural resources is the choice of discount rate, i.e. whether one should choose a high discount rate or a low discount rate. The higher the discount rate, the faster the rate of depletion of the resource in the earlier years and shorter is the interval before which the resource is exhausted. With a higher discount rate, a lower value is placed on the future consumption relative to present consumption. Hence, it is apparent that an optimal depletion policy will prefer current consumption as the discount rises. This is because the aim of the optimal depletion policy is to maximize the discounted net benefits from a given stock of the resource. The discount rate also determines the rate of harvesting (for renewable resources). Therefore, the higher the discount rate, the more intense will be the harvesting and therefore, this will lead to the depletion of the stock. Therefore, it can be seen that high discount rates are not very desirable from the intertemporal point of view. Does this mean that one should use a low discount rate? Low discount rates may imply less direct natural resource use, but they also imply more investment, which in turns requires more natural resource to be exploited, which will increase the overall level of pollution (Markandaya et al 1994). Moreover, there is no guarantee that no serious environmental degradation might take place due to the use of low discount rates. Therefore, low discount rates may also not be the best way out. Often, the expert opinion too is divided on whether one should use a low discount rate or a high discount rate.

To allow for these different views, a sensitivity analysis is performed using alternative discount rates of 0, 3, and 6 % to assess implications of different discount rates on valuations.

Section II: Valuing impacts

In this section, the impacts identified earlier are valued. Table 5.4 below summarizes some of the costs that can be attributed to these impacts, and the techniques that are used to value impacts.

Table 5.4 Main environmental impacts and valuation techniques relevant to this study

Issue	Impacts on health and/or production	Method of valuation
Air quality	Health impacts, esp. TSP, PM_{10}	Workdays lost x (cost of treatment + lost wages)
Water quality (health impacts)	Health impact	Incidence of death x value of life incidence of sickness x (cost of treatment + lost wages)
Groundwater depletion/water shortage (production impacts)	Higher incremental costs of water supply	Increased water supply requirements due to reduced groundwater x higher incremental supply costs arising out of the need to deliver water
Soil degradation	Loss of agricultural output	Agricultural area x marginal productivity loss x market prices
Cropland converted to mining	Loss of agricultural output	Agricultural area x marginal productivity loss x market prices
Clearing of forest land	Loss of timber, MFP, ecological services.	Market prices, imputed values

These impacts have been classified into four types of costs to ensure that there is no double counting:

- Resource costs that relate to mineral and ground water depletion; and to foregone timber and fuel wood from loss of forests[6].
- Environmental costs that relate to loss of environmental services supplied by forests;
- Health costs that relate to air and water pollution, and,
- Social costs that relate to loss of livelihoods from agriculture.

[6] There is a ban on timber logging in Goa; hence there is no market for local timber. So loss of timber and non-timber resources connected with forest clearing is valued based on market data from other states in the absence of a direct market.

Mineral depletion

The objective is to estimate the value of iron ore depletion in the study area. Physical and economic accounts developed to study the depletion of iron ore in the study area are based on the following framework.

OPENING STOCK (Total iron ore reserves)

Changes due to economic activity
- Extraction

Other accumulation (+/-)
- Accretion to reserves (new finds)

Other volume changes
- Catastrophic losses, etc

Total Change in stock

CLOSING STOCK

Figure 5.3 Framework for physical accounting of iron ore reserves

Source. UNSEEA (UN, 2001)

The application of this method for iron ore reserves in the study area (the three clusters of our study area) is detailed in the next section.

Physical accounting

Opening Stock

Opening stock refers to the stock of iron ore reserves at the beginning of the accounting period.

Production

Production refers to the total iron ore mined and sold. A uniform grade of 62% Fe was assumed. Table 5.5 gives the aggregated production data for the three clusters during the period 1991/92-1996/97, the source of which is an earlier study (TERI 1997).

Table 5.5 Production of iron ore in the three clusters of the study area (thousand tonnes)

Year	1991/92	1992/3	1993/4	1994/5	1995/6	1996/7
For clusters I, II and III	12220	11590	12420	14040	15774	12374

Source. TERI, 1997

Accretion

Opening stock of a year refers to recoverable reserves including discovery of any new reserves until that year. Reserve accretion data was not reported by GMOEA or IBM and hence was ignored.

Other volume changes

Volume reductions on account of non-economic factors such as natural disasters were not reported and hence are ignored.

Closing stock

Closing stock refers to the remaining exploitable reserves of iron ore at the end of each period. It, in other words, is the difference between the opening stock and the net changes in stocks due to the discovery of new finds or volume changes due to catastrophic events. Closing stock, in this study can be defined as (due to the absence of new finds or volume changes):

CS = Opening stock- Production

Closing stock for any year would constitute the opening stock of the subsequent year.

Table 5.6 gives the physical accounts for iron ore in the study area from 1991/92 till 1996/97.

Table 5.6 Physical accounting of iron ore in the study area (thousand tonnes)
(For clusters I, II and III)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Opening stock	203590	190550	177010	161530	147790	131652
Production	12220	11590	12420	14040	15774	12374
Closing stock	191370	178960	164590	147490	132016	119278

Monetary accounting

The study uses both the Net Price and the User Cost methods in order to obtain a range of estimate. The Net Price method gives an upper bound and the User Cost a lower bound estimate of the value of the depletion of iron ore in the study area. The Net Price method is estimated as the difference between market price and the unit cost of production including depreciation and profit margin. The total value of depletion is obtained by multiplying the net price per unit and the total production for each year. The User Cost method as discussed earlier follows El Sarafy (1989). This method splits the total resource rent (R1) into its capital components (R-XT), which needs to be reinvested to ensure a perpetual stream of income from the resource and its true income (X) component which can be consumed; r is the rate of return and T is the number of years in which extraction can take place at the current rate.

The user cost method is based on the following formula:

$$R - X = R/(1+r)^{T+1}$$

where

R = p-c =unit value of the resource less the costs of extraction, development and exploration.

X = annual income ensured in perpetuity

r= rate of discount

T = lifetime of the resource.

The user cost component is estimated at 4 discount rates viz., (0%, 3%, 5%, and 6%).

Assumptions

The assumptions made in arriving at the monetary valuation were as follows[7]:

- The export price of iron ore in US$ for each year as provided by GMOEA. The rupee value for each year was obtained by multiplying by the appropriate exchange rate for each of the years.
- The cost of production figures used in this study is based on an earlier TERI study, which estimated the cost separately for north and south Goa for the year 1996-97 (TERI 1997). The weighted average cost of production was based on the average of lower and upper limits of each region, which was based on the respective share of each region in total production. The cost of production for the previous years was estimated by deflating the 1996-97 data by using the 52-week average wholesale price indices (Ministry of Finance, 1999-2000).
- The depreciation rate (as % of the value of the output) is assessed by IBM and provided to CSO for the estimation of net value added by the sector. The depreciation rate used was 4.07% until the year 1993-94 and 3.33% for the following years. Based on the CSO norms, the study also assumed a profit margin of 25% of the value of the output.

The assumptions are summarized in the Table 5.7 below.

[7] These assumptions are the same as those in TERI 2001 and the methodology followed in this section follows the one used in that study.

Table 5.7 Assumptions used for monetary valuation

Year	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Market price (Rs/tonne)	320	396	427	387	410	477
COST - North Goa	138	159	177	194	217	236
- South Goa	156	181	201	220	246	267
Export price	16	15	14	12	13	14
Exchange rate	20	26	32	32	32	35
Depreciation rate	0.04	0.04	0.04	0.03	0.03	0.03
Average life time (In years)	20	20	17	14	11	13

Table 5.8 below provides the monetary valuation of changes over the period.

Table 5.8 Monetary valuation of depletion of iron ore in study area, 1991/92-1996/97 (current prices)

Monetary accounting	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Market price (Rs/tonne)	320	396	427	387	410	477
Profit margin	80	99	107	97	102	119
Production cost (Rs/tonne)	145	168	187	204	229	248
Depreciation (Rs/tonne)	13	16	16	12	13	14
Value of output (million Rupees)	3915	4592	5305	5435	6460	59024
Total value of depletion (Rs/million)						
Net Price method						
Net price (Rs/tonne)	83	114	117	74	66	95
Total rent (Rs million)	1009	1317	1453	1044	1035	1180
Life time (in years)	20	20	17	14	11	13
User Cost method						
User cost (0%)- Rs million	1009	1317	1453	1044	1035	1180
User cost (3%)- Rs million	539	707	843	668	718	776
User cost (5%)-Rs million	358	472	592	500	566	590
User cost (6%)- Rs million	293	387	497	433	503	516

From Table 5.8, it can be seen that the value of depletion has increased from Rs 1009 million, Rs 539 million, Rs 358 million, Rs 293 million in 1991/92 while discounted at 0%, 3%, 5% and 6%, respectively to Rs 1180 million, Rs 776 million, Rs 590 million, and Rs 516 million in 1996/97. It can be seen that the value of depletion is sensitive to two factors, viz. the lifetime of the resource and the discount rate. The table above shows the sensitivity to the discount factor. The value of depletion declines with increase in the discount rate. In other words, the value of depletion for each of the years was the highest for the lowest discount

rate i.e. 0% and was the lowest at the highest discount rate, viz., 6%. However, irrespective of the method, the trend has been that the value of depletion showed an initial increase and then declined only to increase in the year 1996/7 again. The decline in the value of depletion in the years 1994/5 and 1995/6 can be attributed to a fall in the value of the market price and an increase in production costs, which led to a fall in the net price relative to earlier years.
The figure below captures the relationship between the income from mining as obtained from conventional accounts and the value of mineral depletion.

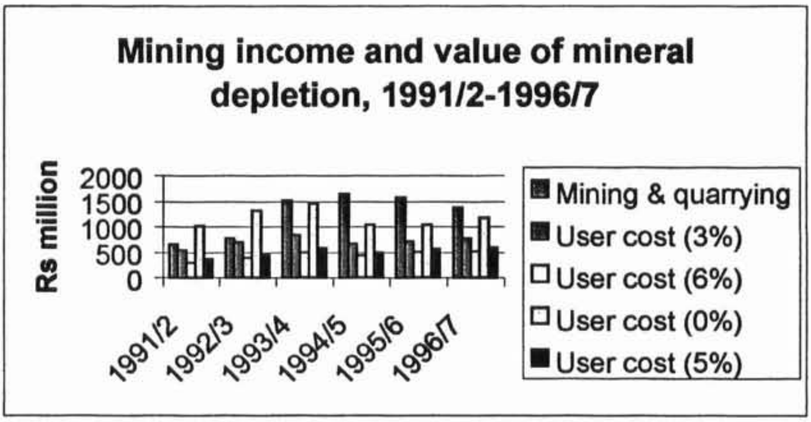


Figure 5.4 Mining income and value of depletion of mineral resources in the study area

In Table 5.9 below, the share of user costs in terms of mining incomes are computed. This ranges from a low of 26% to a high of 169%, again reflecting the sensitivity of the user cost to the discount rates used.

Table 5.9 User cost as share of conventional mining income (%)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
User cost (0%)	156	169	96	64	66	86
User cost (3%)	83	91	56	41	46	56
User cost (5%)	55	61	39	31	36	43
User cost (6%)	45	50	33	26	32	37

Groundwater depletion

Methodology and analysis

In this section the study attempts to value the loss of groundwater as a result of mining. Two major impacts occur due to dewatering of mine pits in area where the aquifers are connected or semi-connected. (1) there is soil desiccation and loss of crop productivity in the surrounding area (2) people become dependent on tanker water as wells go dry. Ideally the method to value ground water loss requires detailed information on the water that is actually pumped out and the net draw down that occurs. The cost of reinjecting water into the aquifer would then be the value of the water pumped out. However, since as discussed earlier, this detailed data are not available, simpler methods were employed by assuming that the impact of lost ground water is reduced agricultural productivity and increased tanker dependence. However, data on the first that is directly connected with loss of soil moisture is not available. So we rely only on the second method, i.e., using the opportunity cost of obtaining tanker water, fully acknowledging the limitations of this method and the lower estimates of groundwater values obtained.

Almost all the households in the mining clusters use multiple sources of water throughout the year. Wells are the predominant source of water for households in the three clusters with 74%, 52% and 50% dependence, respectively (source: Survey, 1996). A significant number of people are also dependent on local rivers and streams for meeting their potable water needs. This is more true of cluster III which demonstrates greater dependence on these sources. Tankers are important sources of water for the households in cluster II. Many households in this cluster experience severe water shortages during the summer months. The water needs of the population are then met by the tanker, which serves the population on a daily basis. It is assumed that dewatering by mining activity causes this shortage as wells run dry around the mining areas. The assumption is that the households, which depend on tankers for water supply, are those where the groundwater has been depleted[8]. In other words, the water supplied by the tankers in each village is the difference between the demand of water and its supply. It is also assumed that the groundwater depletion is mostly during the summer months when the households experience severe water shortages. The physical estimation of ground water depletion is then taken to be that shortage of water, which is made good by tanker water.

The tables below give the number of households in respective clusters reporting use of tankers by quarter (village-wise).

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[8] This, of course implicitly assumes that there is no increase in per capita or total (due to increased population) consumption of water.

Table 5.10 Households reporting usage of tankers by quarter in cluster II

Cluster II[9]	Number of households	June-September	October-February	March-May
Sonshi	4	Y	Y	Y
Pale	17	Y	Y	Y
Pale	1	N	N	Y
Cudnem	2	N	N	Y
Vagueriem	4	Y	Y	Y
Surla	8	Y	Y	Y
Velguem	1	Y	Y	Y
Pissurlem	9	Y	Y	Y
Pissurlem	1	Y	Y	N
Pissurlem	1	N	N	Y

Source. Primary survey

Table 5.11 Households reporting usage of tankers by quarter in cluster III

Cluster III	Number of households	June-September	October-February	March-May
Codli	5	Y	Y	Y
Santona	6	Y	Y	Y

Source. Primary Survey

Since these results are based on the sample where 10% of the households in each village was surveyed, the results of the survey are generalized to the population of the villages and population dependent on tankers for 1 or more quarters is estimated. The following assumptions are made:

Assumptions

- The use of tanker water to meet daily water needs during summer months represents the actual ground water that has been depleted.
- Since the households depend on multiple sources even during summer months, it is assumed that 60% of the water requirements are met by tankers while the rest of the water requirement is met by other sources[10].
- The per capita daily requirement of water in rural areas is assumed to be 150 litres. This may be on the higher side.

[9] Most of the households in cluster II have multiple sources of water. 4 households in Sonshi, 12 households in Pale, 1 household in Cudnem, 4 households in Vagueriem, 4 households in Surla, 1 household in Velguem, 15 households in Pissurlem have multiple sources of water.

[10] Dr. Chachadi, University of Goa.

The cost of having to make good the shortage through water tankers is then valued. Valuation thus uses an opportunity costs approach wherein the cost of depletion of groundwater is taken to be the cost of supply from alternative sources (tankers and pipes).

This is shown in Table 5.12

Table 5.12 Total estimated water shortage per day and during the summer months

Cluster	Water shortage per day (litres)	Water shortage during the summer months ('000 litres)
II	301500	27,135
III	49500	4,455
Total	355540	31,590

Valuation

The value of groundwater depletion is estimated using two costs viz.: 1) the opportunity costs of meeting water needs by tankers 2) the opportunity costs of meeting water needs by pipelines. These are discussed below:

Using tanker costs, the cost of providing the water in the respective clusters by the water tankers is valued at 1996-97 prices. The current (rate) cost of a water tanker of 5000 litre capacity, which is more commonly used than tankers of other capacities, ranges from Rs 160-250. For computational purposes, the current rate is assumed to be Rs 250. In order to convert it to 1996-97 prices, the price is deflated using an assumed inflation rate of 8%. That is,

the price of the water tanker at 1996/97 prices is: Rs $250/(1.08)^4$ = Rs 183.

Therefore the market price of water per litre is Rs 0.036.

Table 5.13 Estimated annual total cost of groundwater depletion

Cluster	Estimated water shortage (000litres)	Annual cost (Rs million)
II	27,135	Rs 0.97
III	4,455	Rs 0.160
Total[11]	31,590	Rs 1.13

Cost of meeting the shortfall through pipelines

Having determined the amount of groundwater depletion in the two clusters, the cost of meeting the additional water scarcity through pipes is estimated. The cost of supplying water through pipes per litre, based on the report of Kirloskar

[11] According to the survey, none of the villages in Cluster I reports the use of water tankers during the summer months.

Consultants (1992) at 1997 prices is 2-5 paise per litre. For computational purposes, an estimate of 4 paise per litre is assumed. It is important to note that the term 'cost' does not imply only the cost of laying additional pipelines, but it also includes water treatment works, reservoirs and pipeline works. Therefore, using an estimate of 4 paise per litre to supply water through pipelines as a proxy for groundwater depletion, the cost of groundwater depletion in each of the two clusters is estimated and is shown in Table 5.14.

Table 5.14 Estimated annual total cost of groundwater depletion

Cluster	Estimated water shortage ('000litres)	Annual cost (Rs million)
I	27,540	Rs 1.1
II	4,455	Rs 0.18
Total	31,590	Rs 1.26

From the above table, it can be seen that pipeline cost yields a marginally higher estimate as compared to the tanker cost approach. Therefore, it can be said that a conservative estimate of the cost of groundwater depletion is in the range of Rs 1.2 –1.3 million. It needs to be pointed out that the depletion of groundwater can also be due to the pressure exerted by the increasing population (both due to natural growth and in-migration) in the study area over the years. However, it is not possible to quantify the ground water depletion solely due to those two factors.

Thus, the annual cost of groundwater depletion by the mining companies is estimated to be in the range of Rs 1.13-1.3 million at 1996/7 prices.

Loss of forests

Goa has been traditionally rich in forest resources. The mining activities have resulted in a considerable loss of forest cover in the mining belt. This has led to the loss of both tangible and intangible benefits provided by the forests. The paper attempts to value the loss of benefits in economic terms due to the mining activity. The objective is to evaluate the net impact of mining on the forest due to foregone timber and fuel wood production had there not been any loss of vegetative cover due to mining. Table 5.15 provides forest area by clusters as defined by the study.

Table 5.15 Forest area by district

Cluster	Area (sq km)
I and II	354.48
III and IV	869.90

Source. Department of Forests, Government of Goa

Note. Cluster IV is not taken into account for valuation in the study.

Uses of forests

Forests serve a range of protective, regulative and productive functions. The different types of forests are a source of both the stock (of wealth) and a series of flows. The table below provides a list of goods and services provided by the forests.

Table 5.16 List of goods and services provided by the forests

Goods provided by the forests	Services provided by the forests
Firewood	Soil conservation
Pulpwood	Protection and regulation of water supplies
Food (tubers, flowers, seeds etc.)	Amelioration of climate
Non-edible oils	Absorption of dust and noise
Medicines	Maintenance of the pool of genetic resource
Fibres and flosses	Habitat for wildlife
Resins	Recreation
Lacs	Maintenance of aesthetics of the environment
Tendu and other leaves	Maintenance of the carbon dioxide balance in the atmosphere
Bamboos and canes	Shelter from hot and cold winds

Source. Lal, J.B (1989)

Use values are defined as accruing from those benefits that are attributed to the present consumption of resources such as wood, non-timber products and tourist services. Indirect values are the environmental services produced by the forests such as the regulation of the hydrological cycle and soil conversation. Non-use values reflect the intrinsic worth of forests independent of society's present use of the resource. On-use values can be further categorized into bequest value and existence value. Existence values refer to the value placed on the 'existence' of the resource even though it may not result in any direct benefits. Bequest values refer to the willingness to pay for the conservation of forests for future generations. Option values on the other hand refer to the value placed on keeping the option of conserving a resource for future use.

Impact of mining on forests: the study area

Mining activities have had a significant impact on forestland in the study area. Based on satellite imagery it appears that a total of about 1854 hectares of land have been lost during the period 1988-97. However, there has been some reclamation of the lost vegetative cover in each of those three clusters. Table 5.17 provides the net loss of vegetative cover across the three clusters in the year 1997.

Table 5.17 Change in vegetative cover (cluster-wise)

Cluster	Vegetative cover lost (ha)	Reclaimed area (ha)	Net vegetative cover lost (ha)
I	365	70	295
II	407	150	257
III	1082	80	1002
Total	1854	300	1554

Source. TERI 1997, Table 3.2

The valuation of loss of forests due to mining follows a two-step process. Firstly, the study attempts to value the loss of economic goods and services (due to the opportunity cost associated with foregone timber and fuel wood production, and non-timber forest produce). Secondly, the study attempts to value the loss of environmental goods and services.

Accounting of loss of economic goods and services

The forests in Goa are mainly tropical type[12] more particularly, either moist deciduous or evergreen. Since 1980, under the Forest Conservation Act, there has been a ban on timber logging in Goa. What logging does occur is illegal and incidental. In this study, therefore, forest loss is associated with the opportunity costs associated with foregone timber and fuel wood production. In order to estimate these two costs, data on the growing stock of timber and fuel wood is required. Ideally, the data should be available for the type of forest being considered and for each of the two forest divisions, North and South Goa. In the absence of any data, the estimates of growing stock for Goa as provided by the FSI (1995) are used. According to these, the growing stock of forests in Goa is 101.16 cu m per hectare. The annual increment is estimated to be 1.848 cu m per hectare. In the absence of forest-specific, *taluka*-specific or division-specific data on the growing stock and after consulting with forestry officials, it has been decided to use the FSI estimates for the current study. Here, we attempt to value the annual

[12] Mr. Kurien, Deputy Conservator of Forests, Goa.

loss of economic goods and services (timber and non-timber forest produce) and environmental goods and services over a period of 50 years. Using these estimates, Table 5.18 shows the annually estimated timber and fuel wood foregone. The Net Price Method was used to value changes.

Table 5.18 Estimated (annually) quantity of foregone timber and fuel wood production

Cluster	Foregone timber and fuel production (th cu m)
I	0.542
II	0.472
III	1.84
Total	2.85

Note. Annual increment of forest is 1.848 cu m per ha (Source: FSI, 1995)

Table 5.19 shows the price of timber and fuel wood.

Table 5.19 Prices of timber and fuel wood (Rs/cu m)

Product	Price
Timber	4390
Fuel wood	722

Source. Department of Planning, Statistics and Evaluation, Goa

It is to be noted that the prices of timber and fuel wood are at 1996-97 levels.

Valuation

The valuation of annual benefits foregone is a three-step process:

- Estimation of the annually foregone timber and fuelwood on the basis of the annual increment of 1.848 cu m per ha at the weighted price of timber and fuel wood.
- Estimation of the annually foregone minor forest produce on the basis of the annual value of output from forest produce (averaged out over the last 10 years at 1996-97 prices) and the total forest area in Goa.
- Estimation of the annually foregone ecological benefits based on the loss of organic productivity.

The per hectare loss is then the present worth of these benefits over a period of 50 years.

The resources (i.e. timber and fuelwood) are valued at the weighted stumpage value, which is the difference between the market price or the economic rent attributable to the resource and the unit cost of inputs and other costs. In order to estimate the stumpage value, the CSO norms are used in absence of actual data. Therefore, costs of material inputs were assumed to be 10% of the value of the output and a 10% trade-and-transport margin was adjusted against the value of the output.

Table 5.20 provides the per unit net price of timber and fuel wood using the Net Price method.

Table 5.20 Per unit net price of timber and fuelwood

	Timber	Fuelwood
Market price (Rs/cu m)	4390	722
Cost (Rs/cu m)	878	144.4
1 Cost of inputs	439	72.2
2 Trade and transport margin	439	72.2
Net price (Rs/cu m)	3512	577.8

Source. TERI (2001)

The weighted price of timber and fuelwood is arrived on the basis of the consumption of timber and fuel wood for Goa[13]. According to Department of Forests estimates, on an average (during the period 1988-89 – 1996-97) the consumption of fuelwood is 1.3 times that of timber, and hence weights of 0.43 and 0.57 are used for timber and fuel wood. The weighted net price is: 0.43*3512+0.57*577.8 = Rs 1839 per cu m.

Table 5.21 shows the annual value of loss of forests associated with the foregone timber and fuelwood which is valued using the weighted net price, while Table 5.22 shows the total net value of loss of forests.

Table 5.21 Annual value of loss of forests associated with foregone timber and fuelwood production

Cluster	Value (Rs million)
I	1.02
II	0.87
III	3.38
Total	5.27

As for minor forest produce, the annual loss per hectare in 1996-97 prices is estimated to be Rs 25. This is estimated on the basis of the value of output from minor forest produce in 1996-97 prices over the last 10 years (Source: DPSE, Goa) divided by the forest area of Goa. Table 5.22 shows the total annual loss of

[13] This is for timber and fuelwood imported into the state.

foregone minor forest (also known as non-timber) produce by cluster. Table 5.23 provides an estimate of the total annual economic value of loss of forests.

Table 5.22 Annual value of loss of forests associated with minor forest produce foregone

Cluster	Value (Rs million)
I	0.007
II	0.006
III	0.024
Total	0.037

Table 5.23 Total annual economic value of loss of forests

Cluster	Value (Rs million)
I	1.027
II	0.876
III	3.40
Total	5.30

From Table 5.23, it is evident that the loss due to clearing of forests is the highest in cluster III.

Accounting for loss of environmental goods and services

In order to estimate the value of the loss of environmental goods and services provided by forests, the data on the annual productivity of the forests by type is required. Kaul (1973) estimated the annual organic productivity of different forest types. Table 5.24 shows the annual average productivity by type.

Table 5.24 Average annual productivity by type of forests

Type of forest	Average organic productivity (t/ha)
Tropical	9.0
Sub-tropical	8.2
Temperate	6.0
Alpine	1.2

Source. Kaul, O.N (1973)

The forests in Goa are of the tropical type. Therefore, based on the norms for tropical forests, the loss of organic productivity in each of the three clusters is worked out.

Table 5.25 Estimated loss of organic productivity by cluster

Cluster	Loss of organic productivity (t)
Cluster I	2,655
Cluster II	2,313
Cluster III	9,018
Total	13,986

Das (1980) used surrogate market techniques to evaluate the benefits provided by a medium-sized tree, which yields a biomass of 50 tonnes over a period of 50 years. According to Das, one tonne of biomass is capable of yielding annual environmental services worth Rs 622 at 1980-81 prices per year. This translates into a value of Rs 2127 at 1996-97 prices (based on the 1996-97 price index) or Rs 19143/ha at 1996/97 prices using the annual productivity of tropical forests at 9 t/ha (ON Kaul, 1973). Using these estimates, Table 5.26 shows the estimated annual loss of environmental goods and services in each of the three clusters in the study area.

Table 5.26 Estimated annual loss of environmental goods and services

Cluster	Estimated loss of environmental goods and services production (Rs million)
I	5.64
II	4.91
III	19.18
Total	29.73

Table 5.27 shows the total annual loss of both economic and environmental services.

Table 5.27 Total annual loss of economic and environmental services (Rs million)

Cluster	Annual loss of economic services	Annual loss of environmental services	Total
I	1.027	5.64	6.66
II	0.876	4.91	5.78
III	3.40	19.18	22.58
Total	5.30	29.73	35.03

Loss of economic and environmental goods and services

Table 5.28 shows the present value of the total annual loss over a period of 50 years at various discount rates.

Table 5.28 Value of total loss of provided by forests (Rs million)

Discount rate	PV at 3%	PV at 5%	PV at 6%	PV at 12%
Cluster I	173.16	106.56	79.92	53.28
Cluster II	150.28	92.48	69.36	46.24
Cluster III	587.08	361.28	270.96	180.64
Total	910.52	560.32	420.24	280.24

The monetary loss due to clearing of forests is estimated to be in the range of Rs 280-910 million. This estimate is on the lower side as the other forest produce and non-use values such as recreation and biodiversity have not been accounted for. If one were to take those into account as well, the loss would be quite significant.

Health costs due to air pollution

This set of costs can be treated either as minimum estimates of the value of air and water pollution or they can be treated as health-related social costs. It has to be said at the outset that this is only an exploratory exercise as the medical data is unsatisfactory. It is being attempted here to illustrate the use of the approach.

Air pollution imposes serious health-related social costs in the form of illness (morbidity) and premature deaths (mortality). The effect of the mining activity in the region can be seen in the increasing ambient concentration of suspended particulate matter (SPM). However, even though, the concentration of SPM has increased over the years, what is of greater concern is the concentration of particulate matter, less than 10 micron in size (PM_{10}) which penetrates the lungs more easily. Therefore, this study primarily attempts to capture the health effects of PM_{10} due to mining activities.

The objective here is to:

i) Estimate the incidence of morbidity in the three clusters due to exposure to PM_{10}.

ii) Estimate the annual health cost due to exposure to PM_{10} in the three clusters.

Methodology

The population of the villages surveyed in each cluster is defined as the population that is exposed to PM_{10}. Once the exposed population is clearly defined, the physical impact or annual health incidences due to exposure to PM_{10} are estimated for each of the clusters. Finally, the physical impact is transformed into economic terms using the Brandon unit values. The estimation of physical impact and the monetary valuation is thus a two-step process:

- The exposed population*dose response function for a health outcome * concentration of PM_{10} >standards for residential areas.
- The physical estimate*unit values (Brandon 1995). The unit values are inflated to 1996/7 prices and then multiplied by the estimated incidence of health outcomes.

In this study, the physical impact of air pollution is first estimated. Since PM_{10} is the major pollutant in Goa, the effects of only PM_{10} on human health are monetized. This is done using Ostro's (1994) dose-response function.

However, sinee the data are available only for SPM and not PM_{10}, we make the assumption that;

$PM_{10} = 0.4(SPM)$[14]

Change in PM_{10} is taken to be annual average concentration minus Indian guidelines for residential areas (100 µg/cu m)

Respiratory hospital admissions (per 100,000) = 1.20 * change in PM_{10}

Emergency room visits (per 100,000) = 23.54 * annual change in PM_{10}

Restricted activity days (per person) = 0.0575 * change in PM_{10}

Bouts of asthma (per person) = 0.0326 * change in PM_{10}

Respiratory symptoms (per person) = 0.183 * change in annual PM_{10}

Chronic bronchitis (per person) = $6.12*10^{-5}$ * change in annual PM_{10}

Valuation of health impacts

This study uses the Brandon unit values which are converted into Indian Rupees at 1996/7 prices for valuing morbidity.

Respiratory hospital admissions and emergency room visits*:* Based on the study by Brandon et al, 1995, the lower estimate for respiratory hospital admission (using the hospital cost approach) is Rs 3108 per case and the higher estimate is Rs 7770 per case. The lower estimate for emergency room visits (using emergency treatment cost approach) is Rs 87.69 and the higher estimate is Rs 219.41.

Restricted activity days: The estimate is Rs 71.41 per day using the daily wage approach.

Respiratory symptoms*:* The lower estimate is Rs 2.49 per day and the higher estimate is Rs 6.66 per day (treatment cost approach).

Asthma attacks*:* The lower estimate is Rs 14.80 per case and the higher estimate is Rs 36.63 per case (treatment cost approach).

[14] Source: Personal interaction with Air Pollution Experts.

Chronic bronchitis: The lower estimate is Rs 65.12 per case and the higher estimate is Rs 162.8 per case.

Analysis

Table 5.29 gives the estimates of the annual incidences (in numbers) due to respiratory disorders in each village cluster-wise. From the tables, it can be seen that the incidence of premature deaths or mortality is lowest in all the villages and also in all the three clusters and the incidence of respiratory symptoms is the highest.

Table 5.29 Estimates of total annual health incidences in numbers in 1997

Cluster	Respiratory hospital admissions	Emergency room visits	Restricted activity days	Asthma attacks	Respiratory symptoms	Chronic bronchitis
I	0.12	2.43	593.74	336.62	1889	0.63
II	5.97	117.17	28622	16227	91092	30.46
III	2.42	47.54	11613	6584	36960	12.36
Total	8.51	167.14	40827.74	23147	129941	43.45

Source. Based on the estimated exposed population (TERI 1997)

Tables 5.30 and 5.31 give the lower and the higher estimates of total annual health cost aggregated for all the clusters.

Table 5.30 Estimates of total annual health costs (Rs thousand) in 1997 (lower estimates)

Cluster	Respiratory hospital admissions	Emergency room visits	Restricted Activity days	Asthma attacks	Respiratory symptoms	Chronic bronchitis
I	0.37	0.21	42.40	0.87	27.96	0.02
II	18.55	10.27	2043.90	42.03	1348.16	1.12
III	7.52	4.17	829.28	17.05	547.01	0.45
Total	26.45	14.66	2915.58	59.95	1923.13	2.03

Table 5.31 Estimates of total annual health costs (Rs thousand) in 1997 (higher estimates)

Cluster	Respiratory hospital admissions	Emergency room visits	Restricted activity days	Asthma attacks	Respiratory symptoms	Chronic bronchitis
I	0.93	0.53	42.40	2.24	69.19	0.10
II	46.39	25.71	2043.90	108.07	3336.70	4.96
III	18.80	10.43	829.28	43.85	1353.85	2.01
Total	66.12	36.67	2915.58	154.16	4759.74	7.07

If one looks at the lower estimates, then the total annual cost of morbidity (excluding premature deaths) is estimated at Rs 4.92 million and the higher at 7.9 million.

The per capita annual cost of morbidity works out to be Rs 205, which is about Rs 17 per month. Assuming an average household size of 5 (as per the census data), the monthly health cost for a household is estimated to be Rs 85 (see Table 5.32). The higher estimate of the annual cost of morbidity works out to be Rs 7.8 million and the per capita annual cost of morbidity is Rs 335, which is about 28 Rs per month. (Table 5.33) Therefore, the average monthly health cost for a household is estimated at Rs 140 (see Table 5.33). If one were to take into account the attendant costs that is, the cost associated with nursing a sick person, the cost will be even higher. However, it is not possible to quantify such costs.

Table 5.32 Per capita monthly health costs and household health costs (lower estimate)

Per capita health cost (Rs)	Average health cost for a household (Rs)
17	85

Table 5.33 Per capita monthly health costs and household health costs (higher estimate)

Per capita health cost (Rs)	Average health cost for a household (Rs)
28	140

The estimate of per capita annual health cost in terms of foregone earnings due to the loss of working days alone is Rs 121. This means a monthly loss of earnings/wages equivalent to Rs 10 per person and Rs 50 per household (assuming a household size of 5). Since the opportunity cost of associated with the lost man days is Rs 50, it indirectly implies that direct out of pocket expenses per month (that is, medicine, consultation etc) for a household is Rs 35 (Rs 85-Rs 50) (lower estimate) – Rs 90 (Rs 140-Rs 50) (higher estimate).

Health cost due to water pollution

Iron ore mining involves the removal of the thick mantle of overburden. This is placed in overburden dumps that are often located near water bodies. Heavy monsoon run-off carries the overflow and washes off rejects into water systems, polluting them. The TERI 1997 study held that the water of the rivers in the study area were mainly affected by high turbidity. The study suggested that the water fell in Class B and C of the Indian ambient water quality standards, which means the water is fit for bathing and for drinking only after conventional treatment and disinfection. However, there is no treatment taking place nor is there any disinfection of stream or river water used by the people. Only a third of the population of the study area has piped water, which is treated. Moreover because of ground water shortages, people have to depend on tanker water to supplement or substitute ground water. Here we attempt to estimate the health costs of lower than good quality water.

Methodology and analysis

The health impact of water pollution is valued as the sum of Medical (direct) cost and RAD's (Restricted Activity Days, opportunity cost associated with the illness) or,

Medical Expenses + RAD's = Total health cost due to water pollution.

According to the India Human Development Report (Shariff, 1998, Table 7.3), the average annual expenditure per person for medical expenses (which includes cost of medicines + consulting) is Rs 89 in Maharashta, Rs 84 in Gujarat and Rs 121 for all-India for short duration morbidity (e.g. diarrhoea)[15]. The figures for Maharashtra are used as a substitute for Goa since Maharashtra is a neighbouring state and also a coastal state like Goa. If the number of persons afflicted with the disease is multiplied by the average annual per person medical expenditure and summed up, it would give us the total medical cost for the three clusters[16]. It is important that the term medical cost not be confused with the term health cost. In order to calculate the annual health costs, the restricted activity days need to be calculated for the villages in the three clusters and also for all the three clusters.

Estimation of restricted activity days

Restricted Activity Days (RADs) represent opportunity cost associated with the illness. That is, it represents the daily foregone wages due to the onset of the disease. According to Brandon (1995), the daily wages is equivalent to Rs 71.14 ($1.93*Rs 37). The same figures are used for the study.

A simple approach to estimate would be to multiply the number of people in the working age reporting diarrhoea in each village by the average duration of the particular disease. Since RAD's refer to workdays lost, one has to be careful enough to exclude the non-working population (children) while computing

[15] It needs to be pointed out that, as per classification given in the Indian Human development report, diarrhea is classified as **short duration morbidity.**

[16] For example, the number of people estimated to be affected by diarrhoea in all three clusters is 34. This is derived from the representative sample survey for the 23 villages across the three clusters where 10% of the households were surveyed in each village. The break-up by male, female and children are: 11, 6 and 17 (TERI 1999, p. 57).

restricted activity days. According to the WHO, the average duration per bout of malaria is 10 days while the average duration per bout of diarrhoea is 5-7 days (for computation the average duration per bout is taken as 5 days). In calculating RADs, care is taken to omit the number of children and the RADs are calculated based on only the number of adult males and females affected by the disease. On the other hand, all the people reporting illness (that is, including children) are taken into account for calculating the monthly medical expenses. The annual health cost due to diarrhoea is then estimated.

Health cost due to water pollution

Tables 5.34–5.36 give the break up of the total health cost by village for each of the three clusters.

Table 5.34 Estimates of total health cost due to diarrhoea in cluster I (Rupees)

	Medical expenses	RADs due to diarrhoea	Total health cost
Total	890	4998	5888

Source. Based on TERI Survey 1997

From Tables 5.34–5.35 it can be seen that the cost imposed by the lost wages is more than the annual medical expenses in all the three clusters.

Table 5.35 Estimates of total health cost due to diarrhoea in cluster II (Rupees)

	Medical expenses	RADs due to diarrhoea	Total health cost
Total	17800	49880	67890

Source. Based on TERI Survey 1997

The tables show that the opportunity cost associated with forgone wages is much more than the medical expenses in cluster I and cluster II and vice-versa for cluster III.

Table 5.36 Estimates of total health cost due to diarrhoea in cluster III (Rupees)

	Medical expenses	RADs due to diarrhoea	Total health cost
Total	18690	7118	26108

Source. Based on TERI Survey 1997

Table 5.37 gives the total health cost for all the three clusters.

Table 5.37 Estimates of total health cost due to diarrhoea (Rupees)

	Medical expenses	Restricted activity days	Total health cost
Cluster I	890	4998	5888
Cluster II	17800	49880	67890
Cluster III	18690	7118	26108
Total	37380	61996	99886

Malaria is the other commonly reported illness in the three clusters. An initial attempt to value the health cost due to malaria revealed that the incidence of malaria tallied with the figures provided by the Department of Health for a few of the *talukas* in which the villages in the selected clusters lie. However, valuation of health impact due to malaria was excluded from the analysis after talks with health officials who revealed that malaria during 1997 was not due to the mining activity in the three clusters[17].

This study yields conservative estimates of the cost of water pollution due to mining. This could be because: 1) valuation of mortality is not attempted due to the lack of data on the incidence of deaths and therefore, only morbidity costs are estimated as annual health cost due to water pollution; 2) It assumes the average duration of the diseases to be equivalent to number of workdays lost due to the disease. This assumption has been made due to lack of any reliable information on average workdays lost due to water-related diseases. Therefore, more specific data relating to variables such as age of onset of disability and age of death are needed for one to arrive at more realistic and accurate estimates of the cost of water pollution.

Social costs due to impact on agricultural land

Mining creates social costs in terms of loss of agricultural livelihoods when cropland is diverted to mining and also when there is a loss of productivity. Cropland productivity loss is the outcome associated with the degradation of soil, either due to silting or due to desiccation.

The objectives of the study are to: 1) assess the economic costs associated with loss in agricultural productivity due to the degradation caused by the mining activity, 2) assess the economic costs associated with the conversion of agricultural land to mining activities.

[17] It is not clear what the causes of malaria in the study area are; but Goa as a whole is a malaria prone area; hence we felt that unless more investigations are carried out, it would not be appropriate to connect malaria with stagnant water in the pits or with reduced immunity of the local people.

Soil degradation in Goa

There are four major types of degradation—soil erosion, salinization, water logging and depletion and/or accumulation of nutrients. However, as far as Goa is concerned, the only degradation that has come about because of mining is depletion of nutrients (due to silting). The agricultural fields in Goa are typically low-lying. Run-off material from dumps and tailing points blank the top organic productive soil of the field. Silt, which is mainly aluminium silicate and essentially inorganic in nature, covering the humus layer, affects the microbial population, and prevents the microorganisms in the soil from fixing nitrogen. If the silt layer is thin, the field needs to be desilted, and organic manures and inorganic fertilizers added to make them productive. If thick, and cultivation is still carried on, then the yield is low despite the use of fertilizers and manures.

Studies in some parts of Goa, indicate that siltation is very heavy. In some cases, the deposits have buried the productive surface soil through a layer ranging from a few centimetres to more than 1.5 or 2 metres deep. The agriculturists, in such situations, have the option of dredging and removing the deposit but once removed, there is no surety of the situation not being repeated. More often than not, they continue the practice until the situation reaches the point of no return. Apart from siltation as a regular feature either through regularly washed down material from upgradient areas, flash flows of heavy amounts of such materials into agricultural fields are another problem faced by agriculturists. Such inflows blanket the productive surface with unproductive raw materials of fine mechanical separates creating an inhospitable soil-water-plant relationship, inhibiting nutritional cycling and balance which finally leads to the loss of top soil. Interpretation of aerial photographs shows that such land affected to differing degrees covers about 320 hectares over various locations of the mining belt. The agricultural land that is affected in the three clusters due to the mining activity is mostly paddy fields.

Methodology

The lack of any data on land affected by mining regions in Goa prevented us from estimating the yield reduction factors for different crops in the three clusters. Due to this limitation, the estimates borrowed from Brandon's study (1995) have had to be relied upon. Further, discussion with the farmers who were affected by mining activities in the three clusters also revealed that the loss in yield was as high as 50% in case of some crops. Therefore, the study estimates the loss in productivity of paddy using Brandon's estimates of yield reduction and the local figure (in consultation with farmers). The yield reduction factors are applied to the productivity of different crops (paddy) and multiplied it by the affected area giving us an estimate of the loss in annual production. Table 5.38 shows the yield reduction factors for the three crops chosen for this study. The physical losses are valued at net market prices in 1996-97 in order to obtain the economic cost of the on-site impact.

On-site physical loss of output = degraded area * productivity loss factor * average annual yield.

Due to the lack of baseline data on crop productivity of the region by village because of the absence of continuous and systematic monitoring, the average yield of crop for the *taluka* is taken as a surrogate for each of the villages in the clusters. The Table 5.39 gives the degraded land in each cluster. Economic loss = physical loss*market price

Table 5.38 Extent (%) of reduced yield in selected crops due to different types of degradation

Depletion of nutrients	Paddy	Coconut (not included in the analysis)	Sugarcane (not included in the analysis)
Low	1	1	1
High	5	5	5

Source. Brandon (1995)

Table 5.39 Total degraded agricultural land area

Cluster	Degraded agricultural land (hectares)
I	89
II	109
III	141
Total	339

Source. TERI (1997)

Tables 5.40–5.42 show the estimated physical loss of paddy based on assumed yield reduction factors and yield on the unaffected land. The product of the eroded land (in ha), the average yield of paddy and the yield reduction factors give the physical loss of paddy in each of the three clusters. Table 5.43 presents the consolidated picture for all the three clusters. The average yield of paddy in the study area is 5,065 kg per hectare. The estimated physical loss of paddy is the highest for cluster III and the lowest for cluster I, and this is because cluster III has a larger proportion of land affected by siltage than the other two clusters. The extent of degraded land (based on satellite imagery) is multiplied by the hypothetical yield reduction factor to arrive at estimates of the physical loss of paddy.

Table 5.40 The physical loss of major crops (in kg) in Goa due to depletion of nutrients in cluster I

Yield reduction factor	Physical loss of paddy
1%	4,508
5%	22,543
50%	2,25,430

Table 5.41 The physical loss of major crops (in kg) in Goa due to depletion of nutrients in cluster II

Yield reduction factor	Physical loss of paddy
1%	4,711
5%	23,556
50%	2,35,560

Table 5.42 The physical loss of major crops (in kg) in Goa due to depletion of nutrients in cluster III

Yield reduction factor	Physical loss of paddy
1%	7,141
5%	35,705
50%	3,57,050

Table 5. 43 The total physical loss of major crops (in kg) in Goa due to degradation

	Total physical loss of paddy (1%)	Total physical loss of paddy (5%)	Total physical loss of paddy (50%)
Cluster I	4,508	22,543	2,25,430
Cluster II	4,711	23,556	2,35,560
Cluster III	7,141	35,705	3,57,050
Total	17,904	89,524	8,95,240

Valuation of physical loss

The physical loss is valued at 1996-97 net market prices. The net market price is defined as the market price net of cost of cultivation and cost of transportation. The net market price of each crop is derived from the net return per hectare and its average yield.

Based on the field data collected by us:

The cost of cultivation for paddy is Rs 30/Kunnagi (a kunnagi is 50 sq metres). Therefore, the cost of cultivation per hectare is: 30*200 (since 1 Hectare is 10,000 sq metres) = Rs 6,000

According to the farmers, the profit per kunnagi is: Rs 125. Or, the profit per hectare translates into Rs 25,000
Therefore, the net return for paddy is: 25,000-6,000 = Rs 19,000
However, according to the Department of Agriculture this estimate is very much on the higher side as compared to their estimates (Table 5.44).

Table 5.44 Net return of paddy for 1996-97

Crop	Cost of cultivation (Rs/ha)	Gross (Rs/ha) income	Net income (Rs/ha)
Paddy	15,131	23,250	8,119

Source. Department of Agriculture, Goa

Data from the above table compared with data collected from field visits, shows that though the net return per hectare differs by as much as Rs 11,000 the gross income per hectare is more or less the same. Therefore, the big difference in the net return per hectare is due to the lower cost of cultivation (based on field data). The cost of cultivation based on field data is much lower because it pertains only to the cost of the seed and does not take into account the cost of fertilizers, manure etc. The cost of cultivation data computed by the Department of Agriculture is higher for precisely the same reason that the cost of cultivation also includes the cost of manure, fertilizers, etc. apart from that of seeds. Therefore, the latter data is used for the computation of net market price. However, this data too does not take into account transportation costs. Therefore, an approximation of the transportation costs (Rs/tonne) is provided for. The net income per tonne (based on the average yield of the crop) net of the transportation cost will give us net price of the crop at 1996-97 prices.

To obtain transportation costs, the total distance (to and fro in kilometres) from the mining villages to the respective *taluka* market is calculated. Since the farmers are basically small farmers, it is assumed that they sell their produce at the respective *taluka* markets rather than the main markets. The total distance travelled in cluster I to the *taluka* market is 16 km, in cluster II, 34 km, and in cluster III, 36 km. The farmers, by and large, use four-wheeler tempos, which are diesel vehicles, for transporting their produce to the *taluka* market. The fuel efficiency of a four-wheeler tempo is 8-10 kilometres per litre. For computational purposes, a fuel efficiency of 10 kilometres per litre is assumed. The carrying capacity of the four-wheeler tempo is about 3 tonnes. Based on the quantity of diesel required and 1996-97 diesel prices, the total cost of transportation per tonne per kilometre is Rs 0.27 and the cost of transportation (across three clusters) per tonne is Rs 24.2.

The net market price for different crops is shown in Table 5.45

Table 5.45 Net market price of paddy (Rs/tonne)

Crop	Net Income	Transportation cost	Net market price
Paddy	1804	24.2	1779.8

Table 5.46 The estimated total economic loss due to depletion of nutrients (valued at net market price of Rs 1779.8/tonne)

	Economic loss of paddy (Rs) (1%)	Economic loss of paddy (Rs) (5%)	Economic loss of paddy (Rs) (50%)
Total	30,545	1,52,728	15,27,280

When cropland is converted to mining: two main type effects can be identified:

Reduced livelihood options: Agriculture in the region is mostly carried out by women. When land is lost to agriculture, this reduces the options of earning income for women. This in turn has implications for choices available to them and is one of the major problems in mining villages. Also in the absence of absorption into mining, those unemployed by loss of croplands, find themselves increasingly marginalized.

A trade-off for short term in place of longer term welfare: When lands are converted, compensation payments are made. Most of these are frittered away quickly as they fall into the hands of rural people unused to large sums of money. Instead of investing, the amount is consumed resulting in short-term gains in welfare, but losses over longer periods.

The estimation of economic cost associated with the loss of agricultural land converted to mining activity is now explained in detail. The methodology is the same as with the valuation of productivity loss. First, the physical loss of crops due to agricultural land converted to mining is estimated. There is a total loss of about 421 hectares of land, which has been converted to mining (mainly cluster I and cluster III). In order to account for the agricultural land, which has been lost to mining, the opportunity cost associated with lost productivity of paddy and pulses is also estimated. Since coconut and cashew are horticultural crops, they cannot be cultivated on agricultural lands; they are not taken into account for estimating the opportunity costs although they are the major crops

During the *rabi* season, paddy can be grown only if there is irrigation. Certain belts in both Bicholim and Sanguem *talukas* are irrigated. As per the data on percentage irrigated area and the total area under cultivation (Source:

Department of Agriculture and Department of Irrigation), it is assumed that 15% of the total area in Bicholim is irrigated and 30% of the total area in Sanguem is irrigated. Based on this assumption, it is assumed that paddy will be cultivated on 15% and 30% of the area lost in clusters I and III, respectively, while pulses grown on the rest of the land had the agricultural land not been lost to mining. During the *kharif* season, it is assumed that only paddy would be grown and not pulses (due to the possibility of water stagnation as the terrain in the mining region is undulating). Based on these assumptions and on the average crop productivity of paddy and pulses during the *rabi* and *kharif* season at the *taluka* level, the opportunity cost of foregone paddy and pulses production during *rabi* and *kharif* seasons is estimated.

Table 5.47 shows the area of agricultural land lost to mining activity in cluster I and cluster III.

Table 5. 47 Agricultural land lost to mining

Cluster	Agricultural land lost to mining (ha)
I	226
III	195
Total	421

Source. TERI, 1997, *Table 3.2*

Table 5.48 Estimate of physical loss of crops (in kg) in the three clusters due to conversion to mining activities (*Rabi* season)

Cluster	Physical loss of paddy in Rabi season	Physical loss of paddy in kharif season	Physical loss of pulses during Rabi season
I	1,70,449	11,39,718	2,11,968
III	2,51,023	66,74,75	57,525

The Table 5.49 gives the total estimated physical loss due to conversion to mining. Table 5.50 provides the estimated economic loss.

Table 5. 49 The total estimated physical loss (in kg)

	Total physical loss of paddy (Rabi and Kharif season)	Total physical loss of pulses (Rabi season only)
Cluster I	1,31,0167	2,11,988
Cluster III	9,18,508	57,525
Total	22,28,676	2,69,513

From the above table, it can be seen that the physical loss of paddy is the highest.

Table 5.50 Total estimated economic loss valued at the net market price (in Rs) of the respective crops

	Economic loss of paddy	Economic loss of pulses
Total	3,964,813	4,231,085

However, since the cropland has been lost to mining over several years and is not a sudden phenomenon, the estimated economic value of the crop loss needs to be discounted. Therefore, the present value of crop loss for 10 years is estimated[18].

Table 5.51 gives the present value of total estimated economic loss over a period of 10 years (1988-97) at various discount rates.

Table 5.51 Present value of the estimated economic loss (Rs million)

	Present value at 3%	Present value at 5%	Present value at 6%	Present value at 12%
Paddy	30.60	30.32	26.63	22.42
Pulses	32.62	32.33	28.39	23.91
Total	63.31	62.63	55.01	46.32

The total estimated economic value discounted at 3% over 10 years is Rs 63.31 million while the value when discounted at 12% over 10 years is Rs 46.32 million.

Conclusion

Summary of costs

In this report, the costs of mining in Goa have been estimated. These are presented by:

- Resource costs that relate to extraction of mineral and ground water and forest timber[19].
- Environmental costs that relate to loss of environmental services provided by forests.
- Health costs that relate to air and water pollution, and,
- Social costs that relate to loss of livelihoods from agriculture

The summary of costs is given in the table below.

[18] It is important to note that we use the present value factors for a discrete series.

[19] Forest loss does involve loss of timber and non-timber resources; however in Goa there is a ban on logging and hence resource values are only used as imputed values of foregone timber.

Table 5.52 Summary of costs (Rs million) from mining impacts

Time periods	Resource costs	Environmental costs	Health costs	Social costs
1996-97	Groundwater depletion: 1.1-1.3		0.1 (water) 4.92-7.90 (air)	Impact on agricultural land 63
1996-97 (5%)	Forest timber and non-timber 85	Forest environmental services 475		
1996-97 (5%)	Mineral depletion: 590			

These figures can be used to operationalize the concept of sustainable development connected with mining operations. The values involved with the environmental costs can be seen as an additional amount that should be contributed by the mining companies to finance environmental rehabilitation using the polluter pays principle. The values under resource, health and social costs can provide the rationale for community development funding. In the case of mineral depletion, this emerges from the fact that once the resource is exhausted there will be no more resource available for the community. Hence a part of the income stream that is generated from the resource (the capital component or user cost) needs to be put away to finance community development so that even when the resource is exhausted the community has the necessary skills and resources for alternative development. Unlike environmental costs, this involves an intertemporal interpretation of opportunity costs. This amount should be set aside year after year and invested to create a perpetual stream of income, that would provide the same level of true income both during the life of the resource as well as after it has been exhausted.

Adjusting the income from the mining sector

At the start of this chapter, a sustainability marker in terms of impact adjusted mining income (I_m) was defined as follows:

Impact adjusted mining income of region (I_m)
= Valued added to GDP by mining in the region (Y_m)
+/- value of mineral resource depletion/enhancement ($V_{md/me}$)
+/- value of environmental degradation/improvement attributed to mining ($V_{ed/ei}$)
+/- value of social impacts attributed to mining (V_{SI})

That is $I_m = Y_m +/- V_{md/me} +/- V_{ed/ei} +/- V_{SI}$

Mining, it was argued, contributes to sustainable development if $I_m \geq 0$. In this last section, the impacts of mining activities have been valued and netted out from the contribution of the mining sector to the state economy, so as to reflect the true income from this sector. Table 5.53 below summarizes this exercise.

Table 5.53 Adjusting income for impact (Rs million)

Year	Value added by 3 clusters to SDP	Value of mineral depletion (user costs)	Value of ground water depletion	Value of forest losses	Health costs	Social costs	Adjusted income or true income
	1	2	3	4	5	6	1 -(2+3+4+5+6)
1996/97	1377	590 (user cost at 5%	1.2	560	7.91	11.5	206.4

Thus the true income from the study area is not Rs 1377 million, but Rs 206 million. That is I_m=206

Data and its limitations

The work embodied in this chapter is an exploratory exercise with a view to demonstrate how the impacts of mining can be netted out of the income as conventionally reported. The exercise made a number of assumptions and worked with a number of data limitations which need to be improved upon. To recap:

1 The health cost of air pollution is based on the borrowed dose-response function and unit values of morbidity. The limitation of the study is that it relies on other studies for dose-response functions and morbidity values as there are no empirically estimated dose-response functions of morbidity for Indian conditions.

2 The health cost of water pollution is based on survey data, which provides information on the number of people reporting water-related diseases such as diarrhoea. The study relies on secondary sources for data on out-of-pocket expenses to estimate the cost of illness. The data on variables such as the age and gender-specific incidence of disease, average age of disability onset, average age of death, monthly per capita medical expenses for Goa, if available, would have helped us to employ more rigorous methods like DALY which would have given us more accurate and reliable estimates.

3 The depletion of groundwater is estimated on the basis of number of households depending on tankers during the summer months. The cost of providing the estimated shortage of water through tankers/pipelines gives

us a monetary estimate. It would have been better to use the aquifer recharge method, for which one needs data on variables such as rainfall in the study area, evapo-transpiration, precipitation etc. which was not available.

4 The estimate of reduced crop productivity is based on hypothetical yield reduction factors, the area of degraded land and the market price of crop (paddy). Data on loss of soil (in tonnes) per hectare in the study area would have enabled us to have our own estimate of yield-reduction factors, which would have given more robust estimates. The estimates of opportunity cost associated with foregone agricultural production is based on the area (in hectares) lost due to mining, the average crop productivity in the study area during *Rabi* and *Kharif* season, net market price of crop and the percentage irrigated agricultural land.

5 The loss of forests is estimated on the basis of the incremental growth of timber and fuelwood and the respective net market prices. To this has been added the value of environmental service as assessed by another study. It is important however, to value environmental services afresh in order to arrive at better estimates. A detailed and a comprehensive study (Contingent valuation method, Travel Cost method etc) is needed to capture the indirect use and the non-use values of forests (biodiversity, recreation etc.) omitted in this study.

6 The depletion of minerals is estimated on the basis of the cost of production, market price and the lifetime of the mines. Much better data are required for production costs across mines, improved reporting of reserves and the need to account for heterogeneous stocks.

6 Conclusion

Mineral development in the mining belt in Goa has contributed both positively and negatively to health and well-being in the region. However, this contribution is insufficiently understood and more importantly, not well communicated externally. This, as a result, has made the stakeholders viz. the Government, the local community and the mining companies, unable to take any purposeful action and participate effectively in decisions that relate to the activity and to progress towards improved well-being in the region. This lack of proper and sufficient understanding of the contribution of the mining activity is possibly due to the asymmetric power relations amongst the stakeholders, which in turn is due to the lack of awareness about the impact of the activity in relation to certain societal goals or standards. In this study, we have developed tools to enable the tracking of health and human well-being in mining regions. If these tools are used regularly, it is believed, that an information system will emerge that will, over time, provide markers of what mining is doing to the region and the communities.

This set of tools, if taken together, provide stakeholders with the following information:

- Indicators will provide trends of what is happening, why it is happening and what responses are emerging;
- The QOL tool will provide information and feedback on the levels of satisfaction among local communities with existing conditions;
- The adjusted income accounts for the region will provide indications of the asset base of the region and therefore, point to the potential for sustaining well-being.

The trends revealed by these tools can help improve decision-making for the sector and the region and shape corrective action by stakeholders. It is proposed that in future research the stakeholders be provided with the capacity to use these tools, and management and other information systems be put in place to enable the use of these tools as sustainability markers in mining regions.

We would like to adopt the framework developed and use it to develop long term projections of what are the possible impacts on health and human well-being in regions driven by human activity. This would enable proactive decision-making by all stakeholders to mining.

Future work

It is proposed that in future research, the framework be extended to enable long-term projections; the stakeholders be provided with the capacity to use these tools, and management and other information systems be put in place to enable the use of these tools as sustainability markers in mining regions.

Future work thus needs to be along three lines:

Research

Using a multi-disciplinary framework that focuses on bio-physical and socio-economic factors and integrates modelling, geographical information systems and participatory appraisal methods, this component would seek to answer the following specific research questions:

- What are the possible trends in future health and well-being in the mining regions given that the mining activity is likely to continue for another 20 years?
- What strategies are possible to enhance the positive contributions and reduce the negative contributions of mining to health and well-being?

Capacity building

- Governments, especially at the local levels, for improved rule enforcement and monitoring through remedying informational failures, generating a mix of cooperation and engagement among various stakeholders.
- Communities and NGO's through improved information, tools and educational support.
- Companies, through improved access to better practices, to innovative approaches to resource transfers for environmental improvements; for improved compliance amongst potential polluters through information dissemination, awareness raising, access to good practices; learning opportunities or forums for middle level executives in mining.

Preparing community toolboxes based on

- What tools exist: networks for information and contacts?
- How tools that we have should be used?
- What tools are needed over and above those we have developed?

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Chapter 4

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