Environmental & Social Performance Indicators and Sustainability Markers in Minerals Development: Reporting Progress towards Improved Ecosystem Health & Human Well-being, Phase III

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Table of contents

Chapter	Title	Page no.
	Acknowledgements	iv
	Glossary of Indian terms	vi
	List of abbreviations	vii
	Executive summary	viii
1	Introduction	1
2	Valuing environmental-health linkages from air pollution in mining regions	6
	Air quality monitoring	12
	Health impact analysis	19
	Economic valuation of the cost of ill health	34
	Health care services	39
3	Land	50
	Impact of mining on agricultural land and employment	50
	Understanding environmental-health linkages: metal uptake in fruit crops grown on overburden dump	60
4	Governance	72
5	Refinement of tools	89
	ESPI tool	89
	QoL tool	94
	Impact adjusted income accounts	96
6	Capacity building and dissemination	100
	Capacity building	100
	Project outputs and dissemination	107
7	Recommendations, impacts and conclusions	112
	Recommendations	112
	Impacts	120
	Conclusions	122
	References	124
	Annexures:	
	Annexure A	1
	Annexure B	24
	Annexure C	32
	Annexure D	76

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Glossary of Indian terms

Anganwadi	State run village nursery and also the focal point for delivery of services at the community level, to children below six years of age, pregnant and nursing mothers, and adolescent girls.
Gram kruti samiti	Village action committee
Gram Sabha	Village assembly comprising the adult population of the village
Mamlatdar	Local magistrate
Pancha/Panch	Elected members of the village Panchayat
Panchayat	The smallest unit of elected local self-government, comprising of a cluster of villages. Representatives are elected from these villages and constitute the Panchayat.
Panchayati Raj	System of rural elected local government at the village, block and district level
Sarpanch	Elected chairman of a village council or Panchayat
Shetki committee/ shetkari committee	Committee or association of farmers in a village
Zilla Panchayat	Elected local government body at the district level
Mahila Mandal	An association of women
Taluka	An administrative unit comprising a number of villages. A number of talukas make up a district.

List of abbreviations

ANM	Auxiliary Nurse Midwife
AAS	Atomic absorption spectrophotometry
AQ	Air Quality
CAO	Chronic Airway Obstruction
CBHI	Central Bureau of Health Intelligence
CHC	Community Healthcare Centre
COPD	Chronic Obstructive Pulmonary Diseases
DHS	Directorate of Health Services
DTPA	Diethylene-triamine-penta-acetic acid
EIA	Environmental Impact Assessment
GMC	Goa Medical College
HIB	Health Intelligence Bureau
IBM	Indian Bureau of Mines
LHV	Lady Health Visitor
LR	Lower Respiratory
MF	Minerals Foundation
MLA	Member of Legislative Assembly
MP	Member of Parliament
MPHW	Multi Purpose Health Worker
NGO	Non Government Organisation
OLS	Ordinary Least Squares
PFT	Pulmonary lung Function Test
PHC	Primary Healthcare Centre
PM_{10}	Particulate matter smaller than 10 microns
PRA	Participatory Research Approach
PWD	Public Works Department
RCD	Respiratory Communicable Disease
RMD	Rural Medical Dispensary
RNCD	Respiratory Non Communicable Disease
R/P Ratio	Reserve to Production ratio
RSPM	Respirable Suspended Particulate Matter
RSQ	Respiratory Symptom Questionnaire
RTO	Road Transport Authority
SC	Sub Centre
SHG	Self Help Group
SPCB	State Pollution Control Board
TB	Tuberculosis
TEA	Total Exposure Assessment
UR	Upper Respiratory

Executive summary

Background

This project was preceded by two earlier phases of research. In Phase I, a conceptual framework for tracking health, well-being and sustainability in mining areas was developed. In Phase II this framework was used to develop a set of three tools to track health and well-being. These tools included a set of Environmental and Social Performance Indicators, a Quality of Life survey tool and Impact Adjusted Income Accounts.

Objectives

The main objectives of Phase III of this study are as follows:

- Understand environmental health linkages in the context of air pollution in the study area, involving:
  - Assessment of exposure to air pollution
  - Assessment of respiratory health status
  - Development of an economic model for the valuation of the cost of ill-health
  - Assessment of health care services in the region
- Assess the impacts of mining on land resources in the region and evaluate the compensation mechanisms in place
- Assess environmental health linkages in terms of land remediation plans with specific reference to metal uptake in fruit crops
- To assess the effectiveness of governance in addressing environmental and social impacts of mining
- Assess how mining affects the well-being of women
- Develop capacity of stakeholders to better monitor and manage environmental and social problems in the study area.
- Refinement of the tools developed in Phase II

Approach and methodology

This study has followed an Ecohealth approach to explore how the impacts of mining on the environment affect local communities. In keeping with this approach, the project has been participatory, involving people from all three stakeholder groups, namely government, the community and industry through the study. The range of research topics in this project have been addressed through a transdisciplinary team of researchers who have worked together to develop a holistic understanding of factors that affect outcomes in the study area. This project has also paid attention to issues of equity through a focus on gender as a cross cutting issue.

The research methodology has included a mix of qualitative and quantitative techniques including household surveys, seasonal air quality monitoring, health tests, focus group discussions, individual interviews, PRA techniques, laboratory experiments, and observation visits to the field. This combination of methods was crucial in developing an well-rounded understanding of the study area.

Results

Environmental – health linkages in the context of air pollution

The total exposure assessment (TEA) model has been used to study air pollution caused by the transport of ore in the study area. Thus, individual exposure to pollution has been captured rather than ambient air quality. This study has also captured the women's exposure to indoor air pollution generated by the burning of bio-fuels for cooking and included this in the analysis. The studies shows that exposure to air pollution (respirable suspended particulate matter) is high in the mining Clusters and transport Corridors as compared to the control area. Exposure between men and women is similar in the mining and Corridor areas. In the Control, however, women have higher exposure to RSPM. As air pollution from mining is not a significant source of pollution in the control area, high exposure among women in the Control can be attributed to burning of bio fuels in the kitchen. More than 90% of the population in the mining Clusters and Corridor areas are exposed to RSPM levels over 150 $\mu g/m^3$ which is the threshold level for industrial areas. Similarly, self-reported health assessments and observed health assessments (through chest x-rays and lung function tests) show higher respiratory problems in the mining and corridor areas than in the control group. The table below summarises the patterns emerging in the study area with respect to air pollution and health.

Table I Air pollution and health status results emerging from various data sets[1]

	Reporting of air pollution (QOL survey*)	Ambient air quality	Average exposure	% of people w/ exposure over 150	Reported lower respiratory illness	Pulmonary function test	X- ray (resp infections and TB)
Most stressed	**Cluster II**	**Corridor**	**Corridor**	**Corridor**	**Corridor**	**Corridor**	**Cluster II**
	Cluster III	Cluster II	Cluster II	Cluster III	Cluster II	Cluster II	Cluster III
	Cluster I	Cluster III	Cluster III	Cluster II	Cluster III	Cluster III	Cluster I
		Cluster I	Cluster I	Cluster I	Control	Cluster I	Corridor
Least stressed	Control	Control	Control	Control	Cluster I	Control	Control

* The QOL survey was conducted in Phase II. There was no road corridor in the QOL survey.

Table I above shows that the Corridor area is most stressed in terms of air pollution and respiratory health. It also shows that Cluster I, the oldest mining area faces the least stress in terms of respiratory health status and air pollution. This could be a result of a lower intensity of mining as mines approach closure phase, and improved access to health care and education (as explained in Phase II of this study).

In order to value the cost of respiratory ill health in the mining regions an econometric model incorporating total exposure assessment and agricultural model was developed. Data emerging from the health and air pollution component fed into the model to arrive at the cost of ill health in the region.

[1] Results from the RSQ have not been included since the analysis from this data is disaggregated for different symptoms.

Table II Summary of annual costs per person and total for doctors visits and wages lost

Cluster	Annual per capita monetary expense due to doctor's visits (Rs./person/year)	Total expense due to doctor's visits per year (Rs./year)	Annual loss of wages per capita (Rs./sickday/ year/person)	Total wages loss per year (Rs./year)
I	324	13,860,720	248	4,000,984
II	428	19,136,308	332	5,877,064
III	316	8,033,036	244	2,608,116
Corridor	640	13,700,480	496	4,020,080
Total		**54,730,544**		**16,506,244**

* Census 2001

The summary table II above highlights the estimated cost of ill health as result of wages lost and expenses incurred for doctors visits. Looking at the Clusters and Corridor together, the estimate of average wages lost per person (in the work force) due to respiratory sick days is Rs. 330 per year. Similarly the average, annual expenses per person due to doctors visits is Rs. 427. The total annual cost of ill health due to doctors visits and wages lost for the mining region is Rs. 71,236,788 (US $ 1,548,626).

Land resources

This study highlights the impacts of mining on agricultural land resources in the region. Run off from poorly managed overburden dumps have resulted in

- Lowered soil fertility
- Reduced water holding capacity of water bodies leading to shortages of water
- Changes in land contour causing water logging and affecting irrigation

While it is possible to overcome some of these problems through technical solutions this drives up the costs of production. This is not an attractive option for farmers as rice is not a lucrative crop and it is grown for self-consumption. The decline in paddy farming in the region has influenced employment opportunities in the region. While mining has provided employment options for men, there are no significant alternative employment opportunities for women.

An agricultural gender map has been used to estimate the number of work days generated per paddy crop, per acre of land farmed, on small farms (less than 1 acre) and large farms (more than 1 acre). The results are summarised in the table II below. Based on these calculations we can therefore assume that for ever acre that is not farmed per season women lose 113 or 53 employment days.

Table III Work days per acre of land on small and large farms

	Small holdings (< 1 acre)	Large holdings (> 1 acre)
Female days	113	53
Male days	88	27
Total	201	80

Using available data on agricultural land lost to mining over a ten year period the total employment days lost per year (including two crops) have been calculated as shown below.

Table IV Total loss of work days per year in agriculture due to mining

Land details	Total land in acres	Male days	Female days	Total
Small holdings (< 1 acre)	177	15576	20001	35577
Large holdings (≥1 acre)	863	23301	45739	69040
Total from first crop	1040	38877	65740	104617
Total from second crop	229	8562	14477	23039
Total	1269	47439	80217	127656

Compensation

Companies have responded to changes in agriculture by providing compensation to farmers for crop loss. Research reveals, however, that the process of compensation payments is problematic for the following reasons:

- Payment of compensation is ad hoc and does not follow a set procedure in terms of setting of rates, recipients entitled, number of payments per year, etc.
- As a result there is mutual distrust between companies and farmers
- There is no monitoring of compensation payments by any state agent and no data available on total land area for which payments have been made or number of payments made.
- The amount of compensation paid is small and therefore does not serve as an incentive towards better dump management by companies.

In addition to companies, there are a range of government departments responsible for regulating mining activities (dump management) and several government departments responsible to manage natural resources (water bodies and agricultural land). However the study shows that their responses have been ineffective in getting companies to comply with regulations and inattentive to farmers needs in the region.

Metal up-take in fruit crops

Vegetation of dumps is a crucial part of remediation measures towards stabilising overburden dumps. NGOs, governments and companies have increasingly realised the importance of growing plants/trees that are beneficial to the local community be it in terms of fodder, fuel, or food. While research shows that local communities prefer fruit trees to be grown on dumps it is necessary to study the implications of using mine reject dumps for food crop cultivation. Through laboratory experiments the metal content in biological samples obtained from eight types of fruit trees, and metal content in soil (total and bioavailable) were estimated for five metals (Fe, Mn, Zn, Cr, Ni). Through statistical analysis cashew samples showed significant relationship between metals (iron, manganese, nickel and chromium) in the plant system and that in the biological samples. No such relationship was observed for Zinc. Of the total 55 samples selected, 43 samples showed significant relationship. This indicates that some plants might be accumulating higher quantities of metals, whereas others do not. A major limitation of this study was the absence of enough fruit trees growing on dumps thereby limiting the number of samples available. As a result, further experiments on a trial plot basis are necessary.

Governance

In terms of governance this study attempted to characterise governance in the study area in terms of responses to air pollution, depleting ground water and deteriorating respiratory health status. The first part of this study involved characterising responses of the three main stakeholders in the study area. Results are summarised in Table V below.

Table V Responses to environmental and social change

Agents	Actions and responses
Government (*Panchayats*, State Government Depts.)	Poor enforcement of legislation, lack of monitoring of envt. and social changes (no data available), lack of clear policies on how to respond to specific problems, not enough consideration given to equity in decision making, responses are unsustainable
Companies	Poor compliance with the rule of law, offer temporary solutions to problems caused by mining, lack of transparency in decision making and actions, lack of company policy on various issues leading to ad hoc responses
Community	Ad hoc responses to problems, very few civil society groups at the local level through which to address issues, willing to compromise on health and well-being for employment, lack of consensus building and attention to equity

The study, focusing on decision making, attempted to identify the motivations and influences on decisions made in response to environmental and social change. Key factors that emerged from the study are listed below:

Table VI Factors influencing responses of agents

Agents	Factors influencing responses
Government	Pressure from political and industrial lobby groups
	Lack of coordination / data sharing between departments
	Graft
	Village politics
	Party politics
Companies	Lack of commitment to CSR
	Profit motive
	Size of company
Community	Nature and intensity of impact
	Lack of unity/village politics
	Dependence on mining for employment
	Lack of leadership
	Lack of information and knowledge
	Age of mining
	Financial constraints

Findings from this component of the study suggest that all three agents need to respond more effectively to changes in the environment and to impacts on the community. While a robust legislative framework is necessary to address these problems, it is clearly not enough to tackle the impacts of mining. While companies need to pay more attention to their legal/statutory obligations and corporate social responsibilities, the state needs to play a more proactive role in monitoring and responding to changes within mining ecosystems by ensuring compliance within industry. The catalyst for this kind of change needs to come from civil society through calls for more information, more transparency and demands for

more accountability. The project has attempted to address these lacunae through capacity building programmes for the local community and through the Indicator tool for government and companies (both discussed below).

Refinement of tools

Findings flowing from these components of the study were used to refine the three tools developed in Phase II.

The Impact Adjusted Income Accounts taken up in Phase II attempted to value the environmental and social costs of mining and accordingly adjust income obtained from mining to reflect true income. One of the limitations in this project was the assumption in valuing health costs of air pollution that the dose response function for developed countries hold true for the study area. Additionally, there was a lack of sufficient information on cost of treatment and disability due to illness. In Phase III, we have improved on this by developing an econometric model to value the health costs of air pollution (as described above).

Table VII below summarises cost estimates from Phase II and Phase III. Cost estimates through the model developed in this project suggest that costs incurred are much higher than those based on developed country models.

Table VII Comparing annual cost estimates from Phases II and III **(Rs. '000)**

Cluster	Phase II				Phase III	
	Lower estimates		*Higher estimates*			
	Total annual wage loss	*Annual medical expenses*	*Total annual wage loss*	*Annual medical expenses*	*Total annual wage loss*	*Annual medical expenses*
I	42.4	29.43	42.4	72.99	4,000.98	1,3860.72
II	2,043.9	1,420.13	2,043.9	3,521.83	5,877.06	1,9136.31
III	829.28	576.2	829.28	1428.94	2,608.116	8,033.04
Corridor	-	-	-	-	4,020.08	13,700.48
Total	**2,915.58**	**2,026.22**	**2,915.58**	**5,023.76**	**16,506.24**	**54,730.54**

The Environmental and Social Performance Indicators developed in Phase II were also refined in Phase III. Maintaining the indicator hierarchy used in Phase II, the indicators were revisited with the following in mind:

- Feasibility and practicality of data collection
- Level of data collection and analysis
- Spatial scale of data
- Applicability to other metallic mining regions
- Incorporation of principles of good governance
- Gender sensitivity

The process of refinement also included the development of a set of guidelines for use by companies and governments.

The Quality of Life survey tool was also revisited in Phase III in order to ensure that any issues emerging through the research were covered and in order to improve clarity of questions where needed. At the conceptual level there were no changes made to the QoL tool. Most of the domains and sub-domains that were developed in Phase II have been retained in the final version of the tool. Some sub-domains were eliminated, though the questions were retained and reorganized under relevant sub-domains in order to maintain logical links with the domains. Additionally, a similar reorganization was also carried out within the sub-domains where some questions were regrouped and reorganised into other sub-domains with the same purpose.

A few questions have been added to the Biomedical domain that emerged as important issues through the health component of the project.

Capacity building

In addition to research, this project also included a capacity building component. Issues that emerged through the research were addressed in this component of the project. Capacity building focused on empowering local community and local elected representatives to ensure that they have the skills and knowledge required to respond to environmental and social impacts of mining. Specifically, programmes and initiatives focused on the following:

- Strengthening local level institutions in the study area (farmers' groups and women's micro credit groups)
- Enhancing the skills and knowledge of local level representatives
- enhancing gender sensitivity
- Disseminating useful information on health (respiratory problems, nutrition, sanitation)
- Creating opportunities for discussion and dialogue among stakeholders

Outputs

1. Compendium of Environmental and Social Performance Indicators for metallic mining regions in India
2. Quality of life survey tool
3. Economic model to value health costs of air pollution
4. Training manual for self-help group trainers

Chapter 1: Introduction

Background

Iron ore mining has been an integral part of the Goan economy for the past fifty years. Mining and allied activities have contributed to the state gross domestic product and simultaneously provide employment to a large percentage of the rural population in the mining belt. Goan iron ore also forms the bulk (60%) of iron ore exports from the country.

Yet, as it is commonly known, the benefits of mining are not without their attendant problems. Mining activities have had an impact on the natural environment, namely air, surface and groundwater and the land adjacent to the mine sites. In addition to changes in the biophysical sphere, the presence of mining for several years has altered the socio-political landscape creating new axes of power and dependence. Collectively, these changes have profound impacts (both positive and negative) on the health and well-being of mining communities.

In Phase I of this project contributed a conceptual framework for the development of a set of tools to track health and well-being and sustainability in mining regions. In this phase, issues of concern in the study area were identified and validated through interaction with stakeholders.

In Phase II these issues of concern were used to develop a set of three tools to track sustainability, health and well-being in the region. The three tools included the following:

- Environmental and Social Performance Indicators (ESPI): a set of indicators to be used by government and industry to track sustainability and well-being in the region.
- Quality of Life survey (QoL): a household questionnaire survey intended to track well-being of mining communities. This survey consists of an objective section to track material conditions and a subjective section that assesses people's satisfaction with their lives and living conditions.
- Impact adjusted income accounts: adjustment of income obtained from mining by accounting for social and environmental impacts.

Objectives

The final phase of research (Phase III) has focused on further exploring issues that constrain or hinder health and well-being in a mining context and on using these findings to refine the three tools developed in Phase II.

Research in Phase III is guided by the following set of questions:

- What are the most significant determinants of health and well-being with reference to the following domains: biophysical, social, economical, biomedical and political?

- What are the reported and observed health conditions of men, women and children in the study villages?
- How can we improve the assessment of the economic burden of ill - health due to air pollution?
- What are the institutions of health care in the region? What is the level of access and use of these facilities?
- Has mining affected the well - being of women differently, and what kind of policy interventions can be put in place?
- How does mining impact land resources in the region and what is the compensation mechanism in place to address these externalities?
- How can we improve recommendations for land reclamation with specific reference to metal uptake in fruit crops
- Who are the actors involved in governance relating to health and well-being issues in the mining region? (Namely air quality, water supply and health-care services)
- How effective is governance in terms of these issues in a mining context? What are the factors/components that promote or hinder good governance?
- What measures can be taken to strengthen governance in the mining region

In addition to the research, Phase III has also included a capacity building component that focused on working with stakeholders to improve health and well-being outcomes in the study area.

Project implementation and management

The research agenda for Phase III included research related to three broad themes as follows:

Land related issues

- Impact of mining on agricultural land
- Impacts of declining agriculture on employment opportunities for women
- Compensation mechanisms in place
- Metal up take in fruit crops used for land remediation

Health related issues

- Assessment of air pollution in the study area
- Assessment of respiratory health status in the study area
- Development of an economic model to value the cost of ill health as a result of air pollution
- Assessment of health care services in the region

Governance

- Characterisation of governance in the region with respect to changes in air quality, changes in ground water, and in terms of tracking health status in the region
- Assessment of factors that influence responses to changing environmental and social systems

Gender

Additionally, gender was explored as a cross-cutting issue in all three themes addressed. In terms of gender, issues that are crucial to women have been specifically probed, such as the impact of mining on groundwater and the loss of agricultural livelihoods among women. Within other components of the project, where possible, data has been disaggregated by gender in order to check whether there are significant differences between men and women in terms of their health and well-being, in terms of the impacts of mining, and in terms of their agency to affect change.

Methodology

The study area as defined in Phase II has been adopted in Phase III and includes 53 villages in the mining regions of Goa classified into three Clusters based on the age of mining. Cluster I is composed of villages where mining has been present for >40 years, Cluster II > 25 years and Cluster III > 15 years. For the health and air quality components of this study an additional area (Curchorem) that is used extensively for the transport of ore but where there is no active mining was selected as a Road corridor. Additionally, a village which has no transport routes running through it and no active mining but is in the same geographical region was selected as a Control village (Rivona).

Given the breadth of topics addressed in this research agenda, a variety of qualitative and quantitative methodologies were used including household surveys, seasonal air quality monitoring, health tests, focus group discussions, individual interviews, PRA techniques, and observation visits to the field. A detailed description of methods used for each component of the study is presented in the following chapters dedicated to each theme.

Disciplinary orientation

A transdisciplinary orientation was necessary for this study given the broad range of issues addressed. The team consisted of individuals with varied backgrounds including statistics, environmental science, economics, political science, public health, hydrogeology, microbiology, agriculture etc. Each team member has brought with them a unique educational background and work experience that has allowed us to characterise problems in the study area more holistically. The study has been enriched by the variety of perspectives that have emerged from our transdisciplinary team.

Additionally, the project engaged four consultants who are experts in their field and assisted with various components of the research. These included a cardio-respiratory specialist, Dr. S. K. Chabbra, from the Vallabhai Patel Chest Institute, New Delhi, who was involved in the health component of the project. He contributed to the study design, reviewed clinical tests and guided the analysis of health data. Dr S. Das, an economist at Delhi University provided guidance for developing an econometric model to value the cost of ill-health. Dr. P. R. de Souza, a political scientist at the Centre for the Study of Developing Societies (CSDS), New Delhi, acted as a consultant for the governance component of the project. Ms. Milan Khanolkar, an artist and social worker, worked with the TERI researchers to implement the Training for Self-help group Trainers programme that spanned ten months. She also assisted with documenting the work done and provided illustrations for the manual that has

been developed. These consultants provided very specific and relevant inputs for the various components in the project.

Involvement of stakeholders

Given the stress on participatory techniques, across all three phases this project has, interacted closely with non-researchers: in defining the problem, testing the earlier tools and now addressing the research issues in Phase III. As TERI has been engaged in research and capacity building in the mining areas for several years, we have developed a rapport with people in the community and the mining industry which has been extremely valuable in eliciting participation and cooperation from these stakeholders during the course of the project. Meetings with various stakeholders such as representatives from mining companies, village Panchayats, local hospitals and the community were held from time to time and their inputs were incorporated to improve the study methodology. Focus group meetings and discussions were very central to the research process.

Research ethics

Given that this project had a strong health focus and the methodology included health tests, some key steps were taken to ensure that ethical standards were maintained through out the project, including the following:

- An Institutional Ethics Committee was constituted based on the Indian Council of Medical Research (ICMR) guidelines and included the following: a medical scientist, clinician, legal expert, social scientist, philosopher, community representative and a representative from the government. The Committee gave its clearance to the project, and provided valuable feedback and guidance through the life of the research. In all, six meetings were held with the Committee, during which the Committee members were updated about the progress of the study and their views and opinions were sought on various ethic- related issues.
- Participants in the study were informed of the objectives of the project and informed consent was obtained for involving the participants, including children in the study.
- Participants were free to withdraw from the study at any time.
- Follow-up visits were taken up for participants whose health tests indicated health problems. Additionally it was made certain that these participants visited their local health centre or family practitioner.

Scientific management

In order to maintain a level of rigour in terms of the research findings, all the components of this project were peer reviewed by colleagues in TERI, New Delhi. Several team members from Goa travelled to Delhi for these meetings and presentations resulted in discussion and several valuable points for further consideration. Additionally, as part of the project team was based in Delhi, this trip presented an opportunity for most of the team members to interact and discuss plans for further integration of findings before October 2006. Additionally, we have had regular visits by various IDRC reviewers, who have provided useful comments and feedback.

Project administration

Given the vast scope of the project, the research agenda was broken down into four sections in order to facilitate efficient management. The team members interacted regularly with each other ensuring that there was a free flow of information and sharing of insights. There has been continuous interaction through face-to-face meetings, short reports, presentations and email communications. In order to improve interaction with team members located in Delhi an audio conferencing facility was set up, which allowed all the members from Delhi to participate in group discussions.

Three months into the project, the Principal Investigator had to relocate to TERI's head office in Delhi and nine months later the PI went on extended leave from TERI. At this time a new project coordinator was selected from the existing team to lead the project for the rest of the duration.

This project was supposed to end on 15th April 2006. However, in consultation with IDRC a six-month extension for this project has been sanctioned. We are grateful for this extension since it provided us with the opportunity to continue with some capacity building programmes for Self-help group trainers, to conduct further analysis of data gathered and to integrate the vast findings generated through the various components of this project.

Structure of the report

This report has been broken down into 7 chapters and also includes an Annexure volume. Chapter I orients the reader by providing the background to this project, an overview of the research questions, and describes the implementation and management of the project. Chapter II presents findings from the air-pollution and health component of the study. Chapter III addresses the land related topics addressed in this project, namely the impact of mining on agriculture, further impacts on employment, especially for women and an analysis of metal up take in fruit crops grown on overburden dumps. Chapter IV presents a synthesis of three detailed governance case studies taken up in the project on air pollution management, ground water management and health care data management. Details of each case study are included in the Annexure volume. Chapter V includes a summary of work undertaken to refine the three tools developed in Phase II. Chapter VI presents the capacity building work undertaken, dissemination efforts and an overview of project outputs. Chapter VII includes a list of recommendations that have emerged from the project, the teams assessment of the impacts of this project and concluding remarks based on the teams assessment of the project as a whole.

The Annexure volume consists of four parts (A-D) corresponding to Chapters II, III, IV and V and includes material relevant to each of these chapters.

Chapter 2: Valuing environmental-health linkages from air pollution in mining regions

Introduction

Mining and associated activities contribute to environmental degradation that leads to adverse heath impact on the population. Air pollution is one of the major environmental hazards related to mining and associated activities. In the mining regions of Goa, trucks plying through residential areas transport ore from the mine site to loading points along the river where the ore is loaded into barges that move down the river to the sea port. Poor management practices like overloading of trucks, speeding on poor roads and inadequately covered trucks lead to spillage of ore in transit. Continuous movement of trucks along road corridors leads to re-suspension of this ore. Fuel emissions from these trucks also add to the pollution levels. Additionally, ore crushing plants, mine pits and overburden dumps, located in close proximity to residential areas, also contribute to deteriorating air quality. As a result of this, in mining areas, workers and the local community are exposed to high concentration of dust/particulate air pollution.

Fine dust particles less than 10 microns in aerodynamic diameter (PM10) are in the respirable range and are responsible for health effects. These soluble air particles (PM10) pass into the blood stream after inhalation and deposit in the lung alveoli in the respiratory system. The site of deposition of the inhaled air particles determines the clinical response. (Health Canada 2003)

Long term exposure to ambient air pollution can cause acute and chronic respiratory diseases such as bronchitis, pulmonary tuberculosis, bronchial asthma, emphysema, upper respiratory illness, cor pulmonale, viral infections like pneumonia, pulmonary irritation and heart problems. Exposure to high levels of particulate air pollution can also cause impaired foetal and infant growth and development (UNEP, UNICEF and WHO 2002).

Literature also points to adverse impacts of inhalation of iron ore or oxides of iron. According to Walczak-Drzewiecka, et.al., (2003) PM_{10} and $PM_{2.5}$ particles from oxides of iron (ferrite, ferrous) cause dysfunction of the respiratory and immune system. Similarly, inhalation of soluble iron ore particles causes cardiopulmonary toxicity with acute or sub acute ozone-induced pulmonary inflammation (Gurgueira et. al., 2002). Inhalation of iron ore dust can also lead to diffuse micronodular lesions in both lung fields and restrictive ventilatory defect. If deposited within a fibrous nodule it can lead to pulmonary siderosis (Yu et. al. 1993). Inhalation of iron ore (radon daughters) and taconite fibres (type of iron ore) mined near Lake Superior have been seen to cause cancer of the lung, bronchus, and trachea (Hemphill 2003).

In developing countries, families with poor economic status use unprocessed solid biomass fuels for cooking and are consequently exposed to high indoor levels of particles, carbon monoxide and other pollutants. This is cause for further serious respiratory health problems.

An individual's exposure to air pollution is dependent on the location of the home relative to the road, occupation, cooking fuel being used and the duration of time spent in polluted areas. Further respiratory health problems in the mining area depends on exposure levels and a variety of socio-economic factors such education, access to health care, nutritional status etc.

It is clear that many epidemiological studies have linked particulate matter exposure to a series of significant health problems, including aggravated asthma, increase in respiratory problems like painful breathing, chronic bronchitis, decreased lung function and premature death (USEPA 2000, Tetre, et. al. 2002, Burnett, et. al. 2000). However, most of the existing evidence on health impacts of air pollution is primarily based on studies conducted in developed countries. Studies on quantitative assessment of exposure to air pollution and health impacts in developing countries are limited.

This study attempts to identify the extent of respiratory illness in the community as a result of exposure to particulate matter and to value the cost of ill health as a result of air pollution in the mining regions of Goa. By estimating the levels of particulate pollution to which people are exposed rather than simply measuring ambient air pollution this innovative study attempts to analyse the links between air pollution and ill health taking into account exposure to different sources of air pollution, including the burning of bio-fuels.

Specifically, this part of the study includes the following components:

- Estimation of exposure to air pollution in the study area
- Assessment of respiratory health status in the study area through subjective (self-reported) and objective (health tests)
- Development of an economic model using the cost of illness approach to value to the cost of ill health related to air pollution
- Assessment of health care services in the region

Each of these components is addressed in sections in this chapter.

Methodology

Sample selection

The study area has been broken into the three mining Clusters (as defined in Phase II), a Road corridor area and a Control area. The three Clusters are active mining areas that have been classified according to the age of mining. Thus, Cluster I is the oldest mining area, followed by Cluster II, and III. The Road corridor has no active mining, but is an area through which there is heavy movement of trucks involved in the transport of ore. The Control area is a village that is in the same geographical region but has no active mining.

A sample from the population was identified for administering a household survey, health tests and carrying out air quality monitoring. Using the previous studies conducted by TERI (1997) in the mining area and research conducted under Phase II of this study a sampling list of villages was prepared. Baseline information such as demographic profile, worker profile, job type, fuel usage, housing characteristics and health data were collected. Additionally,

available secondary information on air pollution levels was considered for sample villages. Based on this a total of 331 households were selected from across three mining Clusters, the Road Corridor and the Control village. Table 2.1, below, provides the list of villages chosen, the number of households selected in each village and the number of individuals selected to participate in the study.

Table 2.1 Sample size distribution across villages and clusters

Area	Villages	Total households	Male	Female	Total Individuals
Cluster I	Piligao	37	94	84	178
Cluster II	Surla, Pale, Pissurlem	101	233	232	465
Cluster III	Sanvordem, Codli-Kiriapal	85	199	202	401
Corridor	Curchorem	40	94	86	180
Control	Rivona	47	95	93	188
Total		**310**	**620**	**604**	**1412**

Air pollution exposure assessment

Air pollution monitoring

Air pollution monitoring in the study involved monitoring of respirable suspended particulate matter (RSPM) levels in important micro-environments where people spend their time , namely:

1. Cooking area during cooking
2. Living room
3. Outdoors
4. Working area (for mining workers and truck drivers)

Ambient and living room micro-environments were monitored for a period of 24 hours. In the cooking micro environment monitoring was carried out during the cooking period (covering 2 or 3 meals cooking in a day) which last about 2 -3 hours in a day. RSPM monitoring in the working place was carried out for working hours in a day (about 8 hours) with the help of low volume personal air samplers.

Time budget survey

A time budget survey (which was a part of the individual survey, discussed below) was conducted among all members of the household on the basis of a 24-h recall. The time budget questionnaire was designed to collect information on time spent by each member in various micro environments and the type of activity they were involved in, in that micro environment on a normal day in the season when the monitoring was carried out. For children, time activity information was collected from their mother.

Time activity patters and concentrations measured in the micro environments were used to reconstruct exposure levels as shown below.

$E_{ij} = \sum k_{=1 \text{ to } m} = C_{ijk} . t_{ik}$

Where:
E_{ij} = the exposure of the ith individual to the jth type of pollutant,
C_{ijk} = the concentration of pollutant type j measured in the kth microenvironment of ith individual
t_{ik} = the amount of time spend by the ith individual in the kth microenvironment.
m = the number of micro-environments

Health assessment

Review of secondary data

Secondary data on respiratory morbidity available from the Directorate of Health Services (DHS) in Goa was collected and analysed to have a preliminary assessment of respiratory health in the study area.

Questionnaire survey

Primary data collection for the health component of the project included a household survey and an individual survey. The first was administered to the head of the household and included general demographic information, nutritional status, household income, education levels, housing characteristics, cooking practices, household health expenditure, etc. The individual survey questionnaire was administered for each member of the household to gather detailed information on personal habits such as smoking, occupation, environmental conditions of the home and work place, mode of transport to work, averting activities followed to reduce the impact of air pollution, awareness about air pollution, costs of treatment etc. The questionnaires was translated into the local language and pilot tested among 30 households. Based on the feed back from pilot test, the final questionnaire was revised and administered to all participants in the study group.

Respiratory symptom questionnaire

Health status of all participants was assessed for health ailments with particular reference to respiratory problems. This is a standardized respiratory questionnaire that incorporates questions pertaining to respiratory symptoms and is used by the British Medical Research Council to detect respiratory illnesses in individuals. This questionnaire was administered as part of the individual survey, which was carried out by trained social workers.

Health diaries

Each household participating in the study was asked to maintain a health diary in a specified format. The diary included type of illness, day of illness, visits to the doctor, work lost, cost of treatment and days of illness. The household health diaries were given to all subjects during the first survey and with an explanation of how to fill in the data in the local language (konkani/ Marathi). During the re-visits it was observed that very few participants had filled in the health diaries. The local assistants then filled in the required information in the health diaries every six months. The diary was collected twice during the project. As a result of poor compliance among most of the subjects the health diaries data gathered did not serve the full purpose and was not used for analysis.

Recall survey

A recall survey was used to ascertain the specific health problems of each individual in each household. Participants could understand the specific symptoms asked in the recall survey and were able to recall the specific illness that occurred in the past 2 weeks. There were no difficulties in gathering the information from subjects.

Health tests

Each voluntary subject in the study was administered a chest X-ray and pulmonary function test (PFT). The pulmonary function tests (lung function test) were carried out by trained technicians.

Clinical diagnosis

Data gathered through the Respiratory Symptom Questionnaire (RSQ) (part of the health survey) and results from health tests (chest X-rays and lung function tests (LFT) were analysed together for each participant in the study to estimate health status of the study population. This analysis was conducted by Dr. Chhabra, a cardio-respiratory health specialist who is a consultant to this project.

Follow-up

All chest X-ray reports were provided to the subjects after the radiologist and the consultant's diagnosis. Additionally abnormal X-rays were given to participants for their perusal and were collected from them after their treatment to refer to them during the sutdy. Subjects whose chest x-rays were found to have deviation from normal or suggested underlying/ potential problems were referred to their local doctors in the area for follow-up and required treatment. The subjects were re-visited with regard to the concerned treatment and follow-up. Subjects who were identified with active tuberculosis (TB) in the study area were motivated and encouraged to seek DOTS (directly observed treatment, short-course) treatment at the respective health centres for follow-up. A few subjects preferred to approach their local private doctors in the area.

Institutional ethics committee

An Institutional Ethics Committee consisting of seven members was set up at the beginning of the project in keeping with guidelines of the Indian Council of Medical Research (ICMR). This committee met six times over the course of the project and reviewed the methodology followed and researchers' interaction with the local community in the health component of the study. All recommendations made by the committee have been strictly complied with over the life of the project.

Economic valuation

A major limitation of the Phase II study was the assumption, in valuing health costs of air pollution, that the dose response functions for other countries hold true for the study area. To overcome this limitation, an economic model establishing the links between (1) air pollution and health, and (2) health and economic benefits has been developed under the guidance of Dr. S. Das, (Professor of Econometrics at the Indian Statistical Institute) who has worked on this project as a consultant.

The modelling exercise used data generated through air quality monitoring, the health tests and the survey to develop a relationship between exposure and health status. This information was then used to value the cost of illness due to air pollution. The micro-econometric model developed in the study is a combination of the total exposure assessment (TEA) model, from the environmental health sciences, and agricultural household model to arrive at the estimation equations, which explains the relationship between the various variables in the data. These estimation equations were used for further econometric analysis to arrive at how the health end points are affected with a marginal increase in exposure to air pollution. Economic cost of ill health in the region was calculated based on the wages lost and medical expenses due to increased morbidity.

Assessment of health care services

Observation visits

Over the course of the project several visits were made to the Primary and Community Health Centres, Sub-centres and Rural medical dispensaries and private health clinics/hospitals in all three Clusters and the Road Corridor. These observation visits were made in order to see first-hand the kind of health care facilities available in the study area.

Interviews

Interviews and informal discussions were held with doctors and other health care professionals and staff in the study area. Additionally, representatives of the Directorate of Health were interviewed.

Focus group discussions

A total of 12 focus group discussions were conducted across the study area in order to understand community perceptions regarding health status, local medical services and risk factors. These FGD were conducted in four separate sessions for men and eight sessions for women across Cluster I (Mayem, Sirigao), Cluster II (Navelim-Amona, Cudnem), Cluster III (Codli, Sanvordem), Corridor (Curchorem) and the Control (Rivona) groups in the study areas. Approximately 10-12 members cutting across different age groups were invited to the meetings.

Survey

A survey taken up under the governance component of this project included some questions on utilisation of health care facilities in the study area. (Details about the survey methodology are included in the governance section.)

Review of secondary data

Secondary data including reports and documents from the Directorate of Health Services were gathered and analysed.

Results

2A Air quality monitoring

As air pollution caused by mining and allied activities has been reported as a major cause of ill health in the study area this component of the study focused on assessing individual exposure to air pollution (respirable suspended particulate matter) within mining communities. Respirable suspended particulate matter (RSPM or PM10) includes dust particles that are less than 10 microns in size and can be easily be absorbed by the lungs.

Rather than look at only ambient air quality, this study has used the Total Exposure Assessment (TEA) approach to studying air pollution in the mining ecosystem. Over a 24-hour period, individuals spend their time in different micro environments (eg. living room, work place, transit to and from work, work place etc.) where particulate matter levels vary. A time budget survey, which was a part of the individual survey questionnaire, was used to identify the main micro environments in which people spend their time and identify the main sources of air pollution in each. Air quality monitoring was conducted in four micro environments, namely the cooking/kitchen area within the home, the living room within the home, outdoors (outside the house in an open space), and at the workplace (mining and trucking work environments). Air quality monitoring for the workplace focused on mining and allied work because these activities are significant source of air pollution. Using information from the time-budget survey on the number of hours spent in each micro environment and the RSPM levels in each microenvironment, it was possible to construct the 24 exposure to RSPM for each participant in the study.

The tables below show average RSPM concentrations in various micro environments in the study area. Average ambient and indoor concentrations are presented cluster-wise. Table 2A.1 shows that average ambient and living room concentrations were highest in the Road corridor and lowest in the Control area.

Table 2A.1 Average PM_{10} concentration (µg/m3) in various micro environments

Mining area	Average PM_{10} concentration (µg/m3) (Ambient and living room micro environments)	
	Ambient (outside the house)	*Indoor (living room)*
Cluster I	224	204
Cluster II	336	302
Cluster III	299	208
Corridor	436	308
Control	102	114

In the following table (2A.2) average concentration in the kitchen and work place are presented. Average concentrations in the kitchen are classified according to the fuel type being used because levels of pollution vary significantly depending on whether biomass fuels are used. Similarly, average concentrations in the workplace have not been classified by cluster. Rather, concentrations have been classified as:

- Indoors (inside the mine office)
- Outdoors (at various outdoor places within the mine site)
- Driving (inside the drivers cabin of trucks being used to transport ore)

This classification is adopted because several people living in Cluster I were working in Cluster II or vice-versa. Similarly, people living in Cluster III were working in the Road corridor and vice-versa.

Table 2A.2 Average PM_{10} concentrations (μg/m3) in kitchen and work micro environments

Kitchen/ cooking micro environment		**Work micro environment**	
Fuels	*Average PM_{10} concentrations (Kitchen micro envt)*	*Workplace*	*Average PM_{10} concentrations (Work micro envt.)*
Biomass	670	Outdoor working	467
Kerosene	325	Inside office	357
LPG	160	Driving	480

Table 2A.2 shows that the levels of RSPM in the cooking area vary significantly ($p<0.05$) across the households depending upon the type of fuel used for cooking. The RSPM levels were found to be highest among the solid biomass fuel users (Figure 2A.2). As expected the use of LPG resulted in the lowest emission of all fuel categories. A majority of households in the study area (76%) used solid biomass, followed by LPG (16%) and kerosene (8%) for cooking during the monitoring period.

Average concentrations at the workplace were highest inside trucks followed by outdoors at the mine site. Except for average ambient and living room concentrations in the Control area and kitchens using LPG, average concentrations in all other microenvironments were well above the 150μg/m^3 threshold limit for industrial areas.

Figure 2A.1, below, shows cluster-wise variations in outdoor or ambient concentrations in the study area. In addition to showing the mean concentrations, this figure shows that the range of concentrations recorded in the three mining clusters were high with Cluster II showing the highest range. The Road corridor and the Control do not show a range because they are smaller areas and we had only one monitoring station in each. The wide range seen in the mining clusters explains that the spatial nature of air pollution is not uniform and some areas in each cluster are more stressed in terms of air pollution than others. The wide range could be due to the location of the village with respect to the mining area as well as proximity to the main road used for transport of ore.

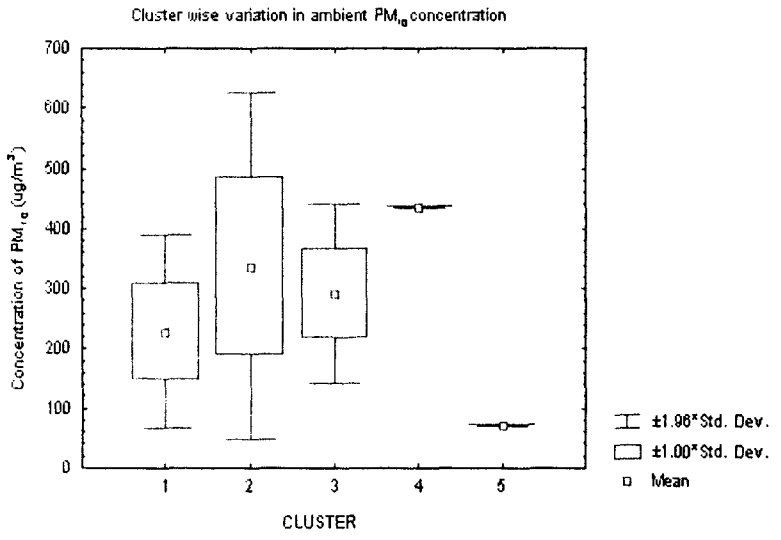
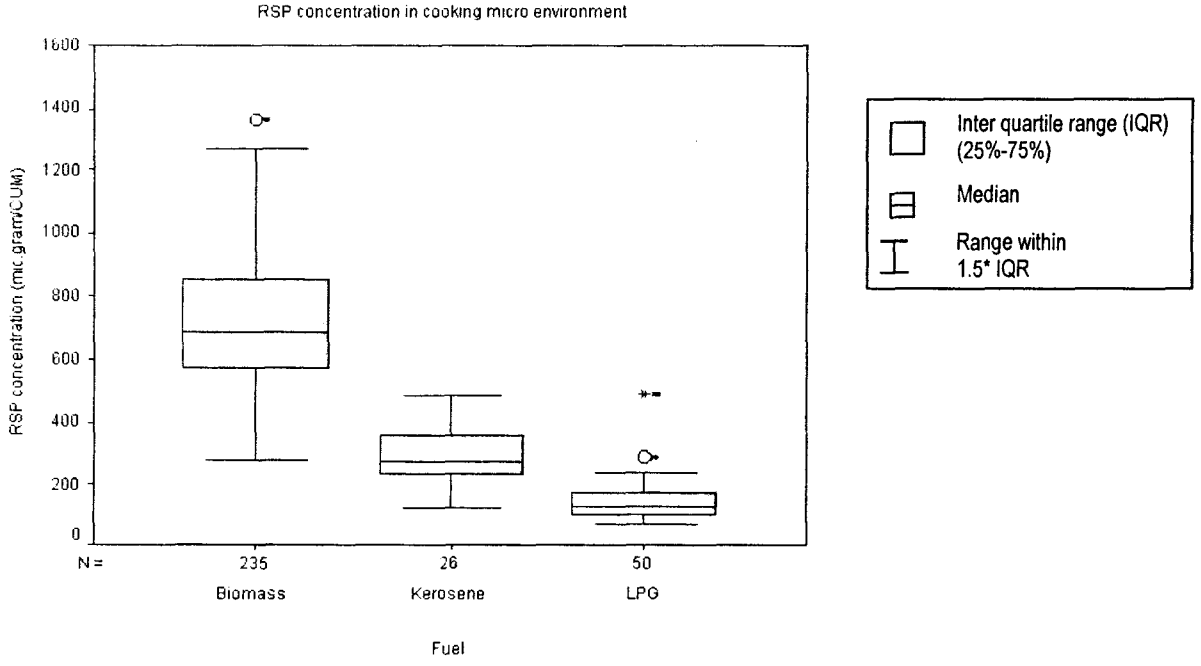


Figure 2A.1 Cluster wise variation in ambient PM_{10} concentration

Figure 2A.2 below, shows the range of concentrations in kitchens using different types of fuel. Among various micro-environments, PM_{10} levels were highest in the cooking micro



environment in households where solid biomass fuels are used.

Figure 2A.2 Distribution of RSPM levels in the cooking area during cooking across households using various fuels

Importantly, the percentage of households using bio fuels across the three mining Clusters, the Corridor and the Control were very similar, i.e 78% in Cluster I; 73% in Cluster II; 71% in

Cluster III; 77% in the Corridor and 76% in Control group were using biofuels for cooking during the monitoring period.
PM_{10} levels measured at various micro-environments were further used to estimate the individual exposure levels. Figure 2A.3 shows the cluster wise variation of individuals' 24-hour average PM_{10} exposure concentration.

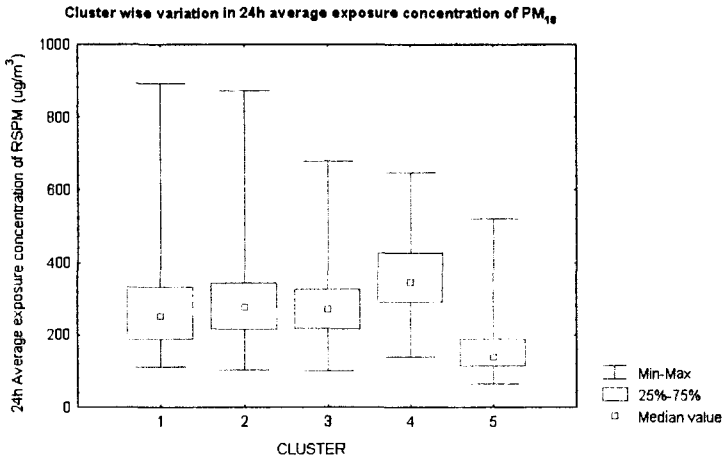


Figure 2A.3 Cluster wise variation in estimated exposure levels of individuals for 24 hour PM_{10} concentration

The above figure reveals that the 24-hour average exposure levels were highest among individuals in Road corridor. Among the 3 mining clusters, little variation is observed in individual exposure to PM_{10}. Average exposure was lowest in the Control village.

In India, national ambient air quality standards have been set by the Central Pollution Control Board. According to national standards 24 hour exposure should not exceed 150 $\mu g/m^3$ in industrial areas[1]. The RSPM standard for residential areas is set lower, at 100$\mu g/m^3$. Figure 2A.4, below, shows that more than 90% of the study population in the mining area (Clusters I, II and III) and the Road corridor were recorded with exposure levels above 150$\mu g/m^3$ whereas in the control group 42% of the population were in the category of exposure levels above 150 $\mu g/m^3$.

[1] The 24-hour average standard should be met 98% of the time in a year. It may exceed 2% of the time, but not on two consecutive days. (National ambient air quality standards, Central Pollution Control Board)

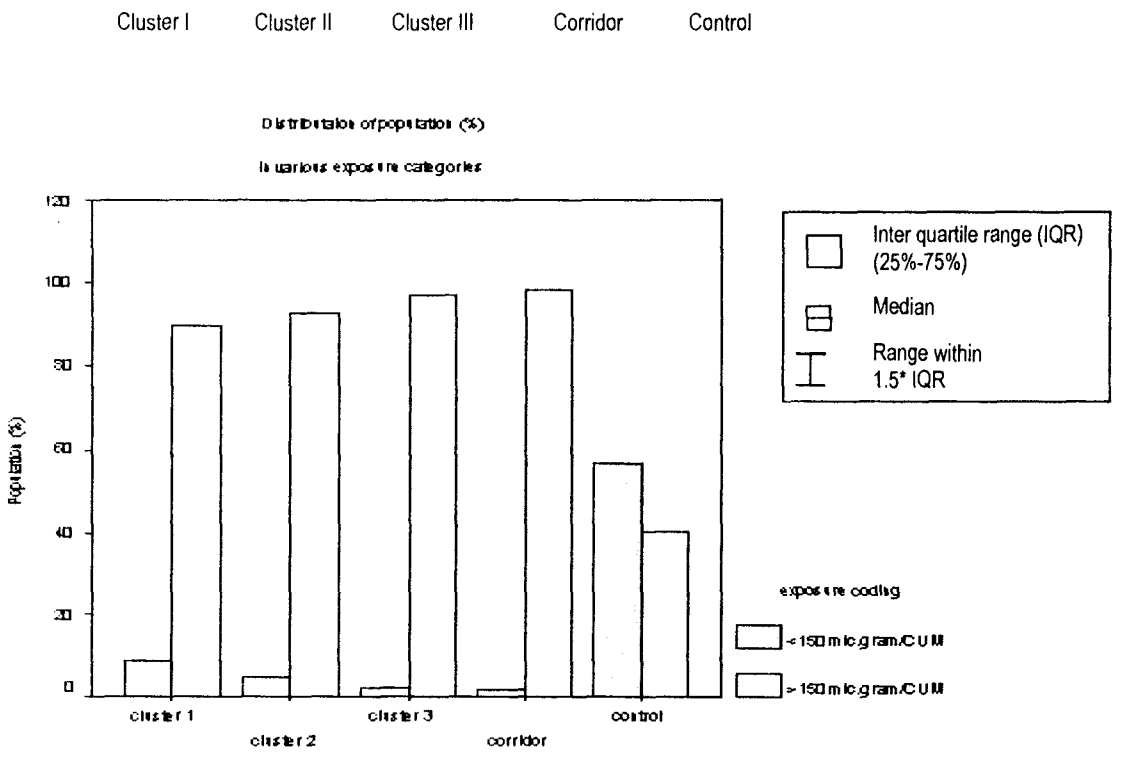


Figure 2A.4 Distribution of population in various exposure categories by Cluster

The study also explored variations in exposure levels among men and women in the study area.

Cluster I Cluster II Cluster III Corridor Control

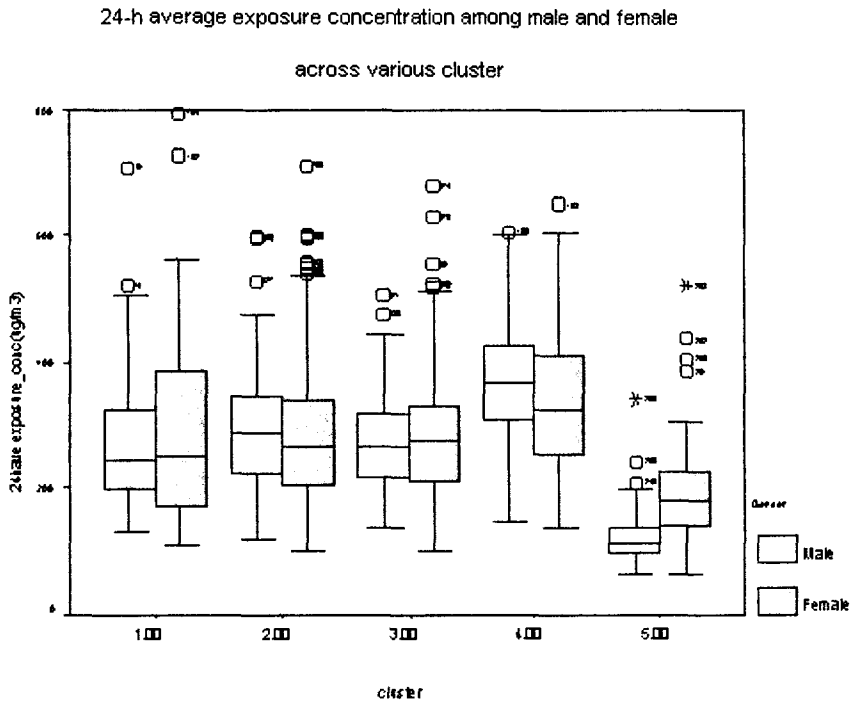


Figure 2A.5 24-hour average exposure concentration among males and females

Figure 2A.5, above, shows that there is not much variation in 24 hour average exposure levels between men and women within each Cluster and Corridor. In the control group females were recorded with higher exposure levels than men. In the Control area, as there is no significant source of air pollution other than cooking. Since women are mostly in the kitchen their exposure level is greater than that of men.

Additionally, we see that women in the control group have much lower exposure than women in the mining Clusters and Corridor. This is because women in the mining areas and Corridor are exposed to air pollution as a result of mining and related activities in addition to indoor air pollution from cooking.

The data presented in the tables above show clearly that particulate matter levels are high in the mining areas (including the road corridor) and are much higher that those recorded in the Control village. Additionally, individual exposure is also higher in the three Clusters and corridor areas compared to the Control.

Highlights

- Average ambient RSPM levels are highest in the Corridor followed by Cluster II, III, and I. Average ambient level in the Control area is the lowest.
- Average ambient RSPM levels in all three mining Clusters and the Road Corridor is higher than the standard of 150 μg /m^3 for industrial areas.
- Average individual exposure in all the mining Clusters and Corridor are above 150μg/m^3. This suggests that the population in the mining areas is at risk of developing respiratory illnesses.
- Average individual exposure is highest in the Corridor followed by Cluster II, Cluster III and then Cluster I. Average exposure is lowest in the Control area.
- Among those working in mining and allied jobs, truck drivers are exposed to the highest RSPM levels followed by people working outdoors at the mine site. In all the work environments average RSPM levels were more than double the 150 μg /m^3 standard for industrial areas.
- The difference between average male and female 24-hour exposure was marginal in each mining Cluster, and the Corridor. However, it is observed that average exposure among women was higher than men in the Control area. This is because women are more exposed to RSPM from the cooking micro-environment which has emerged the highest compared to other micro environments.

2B Health impact assessment

Secondary data

Secondary data from the Directorate of Health Services (DHS) was analysed in order to assess the level of respiratory health problems in Goa as a whole and in the study area.

The study Clusters do no match administrative boundaries and it is not possible to reclassify the data to reflect only the mining Clusters as defined in this project. Therefore data was gathered for the talukas into which the bulk of each Cluster falls.

In each Cluster there is one main health centre serving the population of the Cluster. The health centres serving Cluster I and II are both part of Bicholim taluka[2]. Thus data from Bicholim taluka is reflective of the study population in Cluster I and II. Cluster III falls into Sanguem taluka. Thus, data for this taluka has been used to reflect Cluster III.

The Road corridor is a town in Quepem taluka. As data for the whole of Quepem taluka would be reflective of a much wider population than just Curchorem town (the Road corridor) we attempted to gather data for Curchorem directly from the Community Health Centre (CHC) located in the town. However, data at the Curchorem CHC was not compiled on a regular monthly basis and no data was available for several months.

The Control village (Rivona) in our study is also located in Quepem taluka. The Primary Health Centre (PHC) in Quepem town is the closest health centre to Rivona village and used by residents of the village. However, this PHC is frequented by people from many villages across the taluka and it is not possible to disaggregate the data by village. Thus, as secondary data for the Control village is not available we attempted to use data for the state of Goa as a comparison or control of sorts when studying the mining region.

Table 2B.1 Secondary data source corresponding to study area

Cluster	Town / *Taluka* / State
Cluster I and II*	Bicholim
Cluster III	Sanguem
Road Corridor*	Curchorem town
Control	Goa

Secondary data gathered is classified as respiratory communicable disease (RCD) and respiratory non-communicable diseases (RNCD) and further, it is classified into upper respiratory (UR) and lower respiratory (LR) diseases as explained in Table 2B.2.

[2] Several villages in Cluster II are part of Sattari taluka but are served by a Primary Health Centre in Bicholim taluka. Thus, data from Bicholim health centres reflects Cluster II as well

Table 2B.2 Classification of respiratory illnesses

	Resp. non-communicable diseases	Resp. communicable diseases
Upper resp. (UR) illnesses	Laryngitis, Coryza, Nasopharyngitis (common cold), Sinusitis, Pharyngitis, Tonsillitis	Influenza, Acute resp. infections, Influenza
Lower resp. (LR) illnesses	Bronchitis, wheezing, Bronchial asthma, CAO, Chronic Obstructive Bronchitis, Lung cancer, Lower respiratory tract infection , Consolidated lungs, Cancer of the larynx, Bronchietasis, Bronchiolitis, Emphysema, Pleurisy, Chronic obstructive pulmonary disease (COPD)	Broncho pneumonia, Pneumonia, Pulmonary tuberculosis

A major limitation of the secondary data available in Goa is that approximately only 40 of the 62 healthcare centres in the state are actually sending in their monthly morbidity reports to the Directorate of Health Services (DHS) which means that the data on health status for the state is incomplete. Of the 62 centres in the state, 7 are in the study area. Reporting from these seven centres is also poor, for example data from the Curchorem health centre is incomplete in that there has been no reporting for several months each year (therefore it has not been presented in the tables below). Thus it becomes difficult to draw any credible conclusions from the available data.

Respiratory Non-Communicable Diseases (RNCD) across the State and the mining *talukas*

Table 2B.3 below shows the number of RNCD for the state of Goa for 1999 and 2000. The table shows the total number and the percentage relative to total population. As population data is only available for census years (in this case 1991 and 2001) the growth rate for the ten-year period was calculated and population for the intermediate years was estimated using this growth rate. This method used for all the tables presented.

Table 2B.3 Number and percentage of cases of RNCD in Goa (1999 and 2000)

	1999	2000
Population	1310051	1328726
LR	33816	72070
	2.6	5.4
UR	96295	73871
	7.4	5.6
Total	**130111**	**145941**

Source. 1999 Annual Morbidity Report prepared by DHS based on International Classification of Diseases (ICD)-10. 2000 Annual non-communicable morbidity report prepared by DHS based on Central Bureau of Health Information format.

Table 2B.3, above, shows an increase in the percentage of RNCD cases in Goa between 1999 and 2000. However, this data cannot be compared across the years because the format used to gather and classify the data differs from one year to the next. Data for other years is unavailable for the State of Goa as data gathered from various health care institutions has not been compiled into one report for the state as a whole.

Table 2B.4, below shows the number and percentage of upper and lower respiratory non-communicable diseases in the mining regions over a three year period (data for Curchorem

(Road corridor) was not available). Lower respiratory illnesses appear to have increased each year in Bicholim (Clusters I and II). In Sanguem (Cluster III) as increase is noted between 2002 and 2003.

Upper respiratory illnesses have increased in Bicholim (Cluster I and II) across the years. In Sanguem UR illnesses have increased in 2002 and then decreased in 2003.

Table 2B.4 Number (%) of upper and lower RNCD cases in mining regions (2001-2003)

		Lower resp. illnesses			Upper resp. illnesses		
		2001	*2002*	*2003*	*2001*	*2002*	*2003*
Bicholim	Population	90734	93014	95352	90734	93014	95352
	N	2392	3375	3749	3644	3950	5324
	%	2.6	3.6	3.9	4.0	4.2	5.6
Sanguem	Population	64080	65289	66520	64080	65289	66520
	N	433	488	1400	1356	1927	1291
	%	0.7	0.7	2.1	2.1	3.0	1.9

Table 2B.5 below, shows the total number and percentage of respiratory non-communicable diseases in the mining regions. With UR and LR cases clubbed together, a clear increase is observed across all years.

Table 2B.5 Number and percentage of total RNCD in the mining regions (2001-2003)

		2001	2002	2003
Bicholim	Population	90734	93014	95352
	N	6036	7325	9073
	%	6.7	7.9	9.5
Sanguem	Population	64080	65289	66520
	N	1789	2415	2691
	%	2.8	3.7	4.0

Respiratory Communicable Diseases (RCD) across the state and the mining talukas

In Goa RCD data is to be collected using a standard format (see Annexure C for format). Table 2B.6 shows the number and percentage of upper respiratory (UR) and lower respiratory (LR) and total RCD cases across the state from 2000-2004.

Table 2B.6 Number and percentage of UR, LR and total RCD cases for Goa

Year	Population	UR N (%)	LR N (%)	Total N (%)
2004	1406129	75856(5.4)	19077(1.4)	94933(6.8)
2003	1386365	32409(2.3)	8290 (0.6)	40699(2.9)
2002	1366880	23042(1.7)	7588 (0.6)	30630(2.2)
2001	1347668	28016(2.1)	6849 (0.5)	34865(2.6)
2000	1328726	35055(2.6)	8523 (0.6)	43578(3.3)

Overall, the percentage share of LR cases is low compared to UR cases. This is because there are very few illnesses classified as lower respiratory communicable diseases. From 2000 to 2003 no clear pattern can be seen. Between 2003 and 2004 a big increase in both UR and LR cases is observed.

Tables 2B.7 and 2B.8 show upper, lower and total respiratory communicable diseases for Bicholim (Clusters I and II), Sanguem (Cluster III) and Goa (Control). Data was only available for 2003 and 2004, and here again data for Curchorem (Road corridor) was not available.

Table 2B.7, below shows that upper and lower respiratory illnesses increased in Bicholim, across the years. However, the extremely low number of LR cases in Bicholim in 2003 suggests that reporting by the health centre in that year may have been very poor. In Sanguem an increase in UR cases and a decrease in LR cases is observed. However, here too the extremely low number of LR cases in 2004 suggest that reporting may have been very poor. The percentage of LR and UR cases in Goa increased over the two year period and were consistently higher than the percentage of cases reported in the study area.

Table 2B.7 Number (percentage) of upper and lower RCD cases in mining regions and Goa (2003-2004)

	Upper resp. illnesses			Lower resp. illnesses		
	Bicholim	*Sanguem*	*Goa*	*Bicholim*	*Sanguem*	*Goa*
Population	95352	66520	1386365	95352	66520	1386365
2003	1304	1062	32409	13	100	8290
	(1.4)	(1.6)	(2.3)	(0.0)	(0.2)	(0.6)
Population	97749	67775	1406129	97749	67775	1406129
2004	2435	1312	75856	693	10	19077
	(2.5)	(1.9)	(5.4)	(0.7)	(0.0)	(1.4)

Looking at all respiratory communicable diseases together (Table 2B.8), we see a marked increase between 2003 and 2004 in percentages for Goa state and Bicholim and a slightly less increase in Sanguem.

Table 2B.8 Total number (percentage) of RCD cases in mining regions and Goa

	Bicholim	Sanguem	Goa
Population	95352	66520	1386365
2003	1317	1162	40699
	(1.4)	(1.7)	(2.9)
Population	97749	67775	1406129
2004	3128	1322	94933
	(3.2)	(2.0)	(6.8)

While increases can be observed in respiratory illnesses over the last few years, because of non-reporting and poor compilation of data no conclusions can be made from the secondary data.

Reported health status

Assessment of health status within the community was made through self-reporting of ill health captured through the household and individual survey and through health tests conducted in the study. Here we present findings based on the self-reported health status as captured by the survey.

A survey was administered to 1412 individuals across the study area. A summary of the survey sample is presented in the table below.

Table 2B.9 Sample for the household and individual surveys and air quality monitoring

Area	Villages	Total Households	Male	Female	Total Individuals
Cluster I	Piligao	37	94	84	178
Cluster II	Surla, Pale, Pissurlem	101	233	232	465
Cluster III	Sanvordem, Codli-Kiriapal	85	199	202	401
Corridor	Curchorem	40	94	86	180
Control	Rivona	47	95	93	188
Total		**310**	**620**	**604**	**1412**

In the survey participants were asked to state whether they had episodes of specific illnesses. (For a list of illnesses and people's responses across the various Clusters, Control and Corridor see Annexure B).

Across the study area eye, skin and upper respiratory illness emerged as the most reported illnesses. In the Road corridor and Control group in addition to these illnesses throat and cardiovascular illness were highly reported. These illnesses could be related to environmental factors like exposure to high dust and other factors like age, gender, poor immunity, socio-economic status etc.

Given the focus on respiratory health in this study, illnesses reported in the household survey were classified into three groups, namely:

- Upper respiratory (illnesses and symptoms related to the upper respiratory tract that could be linked to air pollution, but not necessarily prolonged exposure)
- Lower respiratory (chronic illnesses related to the lower respiratory tract that are likely to occur as a result of prolonged exposure to air pollution)
- All other illnesses

The bar graph below shows that upper respiratory illnesses were highly reported in all groups and are most commonly reported in Cluster II and the Control group. High upper respiratory illness in the control group was due to high reporting of dry cough. Forty percent of respondents from the Control reported having a dry cough as compared to 25-36% in the rest of the study area. Non-respiratory illnesses (sensory illnesses, eye and skin problems and heart ailments) were also highly reported and most reported in the Control group, followed by Cluster II, and Cluster III.

Lower respiratory illnesses were least reported in all groups compared to other types of illnesses. Looking at lower respiratory illness reporting across the study areas we see that

reporting is highest in the Road corridor (31%) followed by Cluster III (29%), Cluster II (27%) and Cluster I (20%). Reporting of lower respiratory illness in the Control (22%) is slightly higher than in Cluster I.

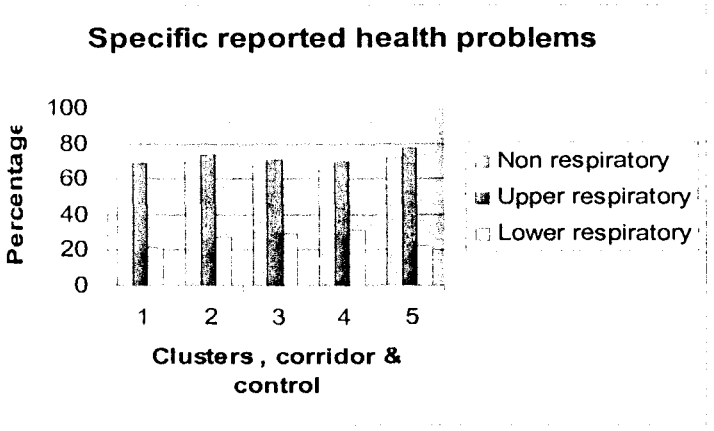


Figure 2B.1 Specific reported health problems across the clusters and control group

Data analysis has focused on identifying patterns in reporting of upper and lower respiratory problems corresponding to demographic characteristics (such as age, migrant status, education etc.) and factors related to RSPM exposure such as distance of home from the road, with the intention of identifying which factors strongly influence or determine respiratory health status in the study area.

Chi-square tests were used to check the statistical significance of the association between various explanatory variables and perceived upper respiratory health conditions. The following tables show significant and non-significant associations using the Chi-square test. A variety of factors such as age, income, education, and distance from road register statistically significant relationships with reported upper respiratory illness.

Table 2B.10 Statistical significance - upper respiratory illness reporting and various explanatory factors

Upper respiratory	Altogether	Cluster I	Cluster II	Cluster III	Cluster IV	Control
Age groups	< .05	< .05		< . 10	< .05	
Years of stay			< .05			
Migrants	< .05			< .05		
Occupation	< .05		< .05			
Income	< .05	< .05		< .10	< .05	< .05
Smoking	< .05				< .05	
Gender		< .10				
Education	< .05	< .05			< .05	
Total exposure						
Distance from road	< .05		< .05	< .05	< .10	
Distance from mines	< .10					

Further logistic regression was used check how all these factors together influence the perceived upper respiratory illness. Distance from the road, age groups, education groups, years of stay in the region and smoking emerged as the significant variables on reporting upper respiratory illness.

As this study is primarily concerned with chronic problems that are likely to be related to mining, more focus was given to analysis of reported lower respiratory problems. Table 2B.11 below, shows reporting of lower respiratory illnesses in different age groups across the study area. The table shows that of those who are under 15 in Cluster I, 4.8% reported lower respiratory illness. Similarly, of those who are between 15 and 29 years in Cluster I, 12.2% of have reported lower respiratory illnesses. The table shows that lower respiratory illness is reported more in the mining areas than the control across all age groups except the over-59 age group. Additionally, reporting is highest in the >59 years group across the study area and the control.

In Clusters I and II a clear pattern of increased reporting with age is observed. In the rest of the study area, reporting of lower respiratory problems seemed to start high, dip in the middle age groups and then rise again in the older age groups.

Relatively high reporting of lower respiratory illness among children (< 15 years age group) in parts of the mining areas is noteworthy. The highest reporting was observed in Cluster III (36%), followed by the Road corridor, Cluster II and then the Control. Reporting of illness among children was least in Cluster I.

While the older age groups (> 59) seem more likely to report lower respiratory illnesses across the study area and the control, age does not display any clear pattern in reporting as far as lower respiratory illnesses go. Yet high rates of reported lower respiratory illnesses in the <15 years group is of concern since damage to the respiratory system in the early years of life implies increased risk the later years of life.

Table 2B.11 Age wise reporting of lower respiratory illness

Cluster		< 15 yrs	15-29 yrs	30-44 yrs	45-59 yrs	> 59 yrs	Total
I	Number	1	9	8	12	7	37
	Percent (%)	4.8	12.2	25.0	33.3	46.7	20.8
II	Number	16	31	27	24	26	124
	Percent (%)	20.0	19.9	25.0	35.8	50.0	26.8
III	Number	31	31	23	17	16	118
	Percent (%)	36.0	24.4	24.0	32.1	41.0	29.4
Corridor	Number	10	14	11	8	13	56
	Percent (%)	32.3	29.8	24.4	25.0	52.0	31.1
Control	Number	7	3	9	7	16	42
	Percent (%)	18.4	6.8	20.9	23.3	53.3	22.7

Table 2B.12, below, shows reporting of lower respiratory problems in the study area by gender. Across the study area (including the Control) reporting of lower respiratory illness

was higher amongst men by between 1% and 3%. The exception is Cluster II where a greater percentage of women reported lower respiratory illnesses.

Table 2B.12 Reported lower respiratory symptoms across gender

Clusters		Male	Female	Total
I	Number	21	16	37
	Percent (%)	22.3	19.0	20.8
II	Number	58	66	124
	Percent (%)	24.7	28.7	26.7
III	Number	60	58	118
	Percent (%)	30.3	28.6	29.4
Corridor	Number	30	26	56
	Percent (%)	31.9	30.2	31.1
Control	Number	22	20	42
	Percent (%)	23.4	21.3	22.3

Table 2B.13 (below) shows the educational backgrounds of the people reporting lower respiratory health problems in the various clusters. The table below show highest levels of reported lower respiratory health problems among illiterates in the study area and the control. The highest reporting is observed in Cluster II with 45.1% of illiterate population reporting lower respiratory problems. A distinct pattern of decreased reporting with increasing education can be seen in all groups.

Table 2B.13 Reporting of lower respiratory illness by education groups

Cluster		Illiterate	Upto std. 10	Above std. 10	Total
I	Number	17	14	5	36
	Percent (%)	38.6	19.2	12.5	22.9
II	Number	41	48	19	108
	Percent (%)	45.1	28.1	15.4	28.1
III	Number	19	29	39	87
	Percent (%)	33.9	26.6	26.0	27.6
Corridor	Number	9	14	23	46
	Percent (%)	37.5	36.8	26.4	30.9
Control	Number	19	12	4	35
	Percent (%)	33.3	24.5	9.1	23.3

Chi-square tests were used to check statistical association between various explanatory variables and perceived lower respiratory health conditions. The following tables show significant and non-significant associations using the Chi-square test.

Table 2B.14 Statistical significance – lower respiratory illness reporting and demographic factors

Lower respiratory	Altogether	Cluster I	Cluster II	Cluster III	Road Corridor	Control
Age groups	< .05	< .05	< .05			< .05
Years of stay		< .05				
Migrants		< .05				
Occupation	< .05		< .05			
Income			< .10			< .05
Smoking	< .05	< .05	< .05	< .05	< .05	< .05
Gender						
Education	< .05	< .05	< .05			< .05
Total exposure						
Distance from road				< .05	< .05	< .05
Distance from mines	< . 10	< . 10		< .10		

Age, smoking, and education and distance from the road showed significant results with lower respiratory illness among individuals in the total study area. Logistic regression is used to check how all these factors together influence the perceived lower respiratory illness. Distance from the road, age groups, education groups and smoking are the significant variables on reporting lower respiratory illness.

The table below shows the relative risk of lower respiratory illness across the mining Clusters and the Corridor area.

Table 2B.15 Relative risk of lower respiratory illness across the study area

Area	Relative risk	Confidence interval 95%
Cluster I	0.93	0.63 - 1.38
Cluster II	1.19	0.88 - 1.62
Cluster III	1.32	0.97 - 1.79
Mining areas (Clusters I, II, III)	1.23	0.92 - 1.62
Road Corridor	1.39	0.99 - 1.96

Control group total sample = 185
Number reporting Lower Resp. Illness = 42

Table 2B.15 shows that based on reporting of lower respiratory sickness, the risk of developing lower respiratory illness relative to the Control is highest in the Road Corridor (39%) followed by Cluster III (32%) and II (19%). The table also shows that there is no risk of developing lower respiratory illness in Cluster I relative to the Control. As a whole the people in the mining regions have 23% risk of having LRI compared to the control group.

Highlights (Reported health status)

- As per the reported health status, eye, skin and upper respiratory illness are major health ailments across all groups.
- Reported upper respiratory symptoms were highest among the Control group followed by Cluster II, III the Corridor and finally Cluster I.
- Reporting of lower respiratory symptoms which are more likely to be caused by long-term exposure to air pollution was highest in the Corridor group followed by Cluster III, II, the Control and Cluster I.
- There is no significant variation between males and females in the study group in reporting respiratory health.
- Age, education and smoking emerged as statistically significant variables in terms of reporting of lower respiratory illnesses.
- Distance of the home from the road also emerged as a statistically significant variable. This is important because air pollution in the mining areas is primarily caused by heavy vehicular traffic movement.

Observed health status

Results of observed respiratory health status are based on data gathered from the Respiratory Symptom Questionnaire, chest X-rays and pulmonary function tests and a cardio-respiratory specialist's diagnosis.

The respiratory problems were studied for 1411 participants, distributed across the various groups as follows: Cluster I (12%), Cluster II (33%), Cluster III (28%), Road Corridor (13%), and the Control group (13%).

The prevalence of respiratory symptoms across various clusters based on the Respiratory Symptom Questionnaire (RSQ) is presented in the following table.

Table 2B.16 Prevalence of respiratory symptoms across the study area based on the RSQ

Symptom	Numbers (%) of population reporting respiratory symptoms					
	Cluster I	*Cluster II*	*Cluster III*	*Mining area (Clusters I-III)*	*Corridor*	*Control*
Cough	9 (5)	21 (4)	18 (4)	48 (4.6)	7 (4)	4 (2)
Phlegm	7 (4)	19 (4)	8 (2)	34 (3.3)	4 (2)	2 (1)
Breathlessness	9 (5)	27 (6)	26 (6)	62 (6.1)	9 (5)	10 (5)
Wheezing	5 (3)	20 (4)	10 (3)	35 (3.4)	7 (4)	11 (6)

The above table revels that the prevalence of cough and phlegm were high among people in the mining area and Corridor area when compared to the Control group. However wheezing was higher in the control group.

The relative risk of respiratory symptoms against the control group population was calculated using the EPI Info package and results are presented in the following table. Numbers within parentheses indicate the confidence intervals.

Table 2B.17 Relative risk (and 95% confidence intervals) for respiratory symptoms when compared to control group

Symptom	Relative risk (95% CI)			
	Cluster I	*Cluster II*	*Cluster III*	*Corridor*
Cough	2.35	2.24	2.28	2.23
	(0.75-7.42)	(0.79-6.38)	(0.79-6.58)	(0.67-7.39)
Phlegm	2.46	2.70	1.40	1.74
	(0.65-9.28)	(0.81-8.94)	(0.38-5.18)	(0.40-7.59)
Breathlessness	0.70	0.85	1.30	1.0
	(0.24-2.08)	(0.37-1.94)	(0.59-2.86)	(0.36-2.78)
Wheezing	0.45	0.83	0.51	0.86
	(0.16-1.26)	(0.41-1.67)	(0.22-1.16)	(0.35-2.13)

The above table reveals that the risk of developing a cough in the mining areas and Road corridor is more than double relative to the control population and relative risk for phlegm ranges from 1.40-2.7 times relative to the control group.

Regression analysis of respiratory symptoms with age, sex and exposure variables shows that elderly people (above 60 years) are more vulnerable to lower respiratory outcomes ($p < 0.01$). There was no significant difference between men and women with respect to respiratory symptoms.

Consistent and valid spirometry[3] (lung function test) results were screened by the cardio-respiratory specialist engaged for this study. Observed Forced expiratory volume in one second (FEV1) and Forced vital capacity (FVC) values were compared with predicted values obtained from the available literature for normal healthy population of similar ethnic group. The FEV1/FVC ratio was calculated and the results were used to diagnose the respiratory problems. As per the GOLD (Global Initiative for Obstructive Lung Diseases) FEV1 <80% of the predicted value and an FEV1/FEC ratio of <70% confirms the presence of air flow limitation. Summary results are presented in the following table.

Table 2B.18 Diagnosis of lung function test results across the study area

Study area	Number (%) of population		
	Obstructive lung function	*Restrictive lung function*	*Normal lung function*
Cluster I	2 (2)	0	99 (98)
Cluster II	5 (2)	4 (2)	203 (96)
Cluster III	6 (3)	4 (2)	196 (95)
Mining area (Clusters I-III)	13 (2.5)	8 (1.6)	498 (96)
Corridor	1 (3)	6 (8)	67 (91)
Control	0	1 (1)	102 (99)

The highest percentage of obstructive and restrictive lung function were observed in the Road corridor followed by Cluster III, II and I. Obstructive and restrictive lung function was lowest in the Control group.

Table 2B.19 Relative risk of reduced lung function across Clusters

Area	Relative risk	Confidence interval (95%)
Cluster I	2.04	0.19 - 22.14
Cluster II	4.37	0.56 - 34.05
Cluster III	5.00	0.65 – 38.53
Corridor	9.74	1.22 – 77.52
Mining (Clusters I-III)	4.17	0.57 – 30.64

Table 2B.19, shows that the relative risk of reduced lung function (obstructive and restrictive lung function) is nine times higher among Corridor group when compared to the Control group population and 2 to 5 times higher in the individual mining Clusters. Looking at the mining Clusters together, relative risk is 4 times higher than the Control. It should be noted that air pollution and exposure levels were also highest among people living in the Road Corridor areas followed by people living in the three Clusters.

[3] As some participants were unable to perform the pulmonary function tests correctly, all readings were not valid. Analysis by the cardio-respiratory specialist is based only on the valid readings.

Analysis of X-ray results shows that between 91% -96% of the observed X-rays were normal across all groups in the study. Respiratory problems (TB/ infections) were highest in Cluster II (4.65%) followed by Cluster III (3.75%), Cluster I (3.15%), the Road Corridor (3%) and the Control (2.4%). One percent or less cardiac problems were observed in Cluster II, III and the Control.

Table 2B.20 Clinical diagnosis of X-rays

X Ray	Cluster I N (%)	Cluster II n (%)	Cluster III n (%)	Road Corridor n (%)	Control n (%)
Normal	106 (93)	281 (93)	218 (91)	96 (96)	116 (91)
Cardiac problems	0	3 (1)	2 (.83)	0	1 (.8)
Respiratory infection/TB	4 (3.15)	14 (4.65)	9 (3.75)	3 (3.00)	3 (2.4)
Humps/lesion	0	0	0	0	2 (1.6)
Skeletal problem (Fracture/kyphoscoliosis)	2 (1.75)	3 (1)	3 (1.25)	0	5 (4)
Not able to diagnose	2 (1.75)	0	8 (3)	0	0
Total number	114	301	240	100	127

Table 2B.21, below shows the risk of developing respiratory illness in the mining Clusters and Corridor relative to the Control group, as detected through x-rays. The highest relative risk is observed in Cluster II followed by Cluster III, Cluster I and finally the Road corridor.

Table 2B.21 Relative risk of respiratory illness diagnosed through chest x-rays

Area	Relative risk	Confidence interval 95%
Cluster I	1.44	0.33 – 6.30
Cluster II	1.88	0.55 – 6.43
Cluster III	1.57	0.43 – 5.70
Road Corridor	1.20	0.25 – 5.82
Mining (Clusters I- III)	1.69	0.52 – 5.50

Major respiratory symptoms reported in the respiratory symptom questionnaire (such as breathlessness, wheezing, cough, and phlegm), pulmonary function test results and X rays were analysed by the cardio-respiratory specialist to identify cases of bronchitis, chronic obstructive pulmonary diseases (COPD), and Asthma.

Table 2B.22 Prevalence respiratory ailments across the study area

	Cluster I n (%)	Cluster II n (%)	Cluster III n (%)	Road Corridor n (%)	Control n (%)
Bronchitis	5 (2.8)	18(3.8)	6(1.5)	5(2.8)	3(1.6)
COPD	2(1.1)	7(1.5)	4(1.0)	4(2.2)	2(1.0)
Asthma	1(0.6)	8(1.7)	4(1.0)	3(1.6)	2(1.0)
Total examined	177 (100)	465 (100)	401 (100)	180 (100)	188 (100)

Among all participants screened for respiratory symptoms, The prevalence of all respiratory ailments together emerges highest in Cluster II (7.10%) followed by the Road Corridor (6.67%), Cluster I (4.52), the Control area (3.72) and Cluster III (3.49%).

The prevalence of Bronchitis (4%) and asthma (1.72) were highest in Cluster II. Prevalence of COPD was highest in the Road corridor (2.22%). Bronchitis emerges as the highest diagnosed illness in all three clusters, the road corridor and the control.

Highlights (Observed health status)

- Analysis of observed health data (diagnosis based on response to respiratory symptom questionnaire, Lung function test and chest X ray analysis) indicates high prevalence of respiratory morbidity in the Corridor and mining area (Clusters I, II, III) when compared to control group. [It is noteworthy that these groups (Corridor, Clusters II, III and I) had high ambient concentrations of air pollution and high exposure levels compared to the Control group.]

- The risk of developing a cough in the Corridor and mining Clusters is double relative to the control group.

- Among all participants screened for respiratory symptoms, the prevalence of respiratory ailments was highest in Cluster II (7.10%) followed by the Road Corridor (6.67%), Cluster I (4.52), the Control area (3.72) and Cluster III (3.49%).

- In the Road corridor, the risk of developing obstructive/restrictive lung function is nine times higher relative to the control group. In the mining Clusters the risk is between 2 and 5 times higher than the Control group.

- There is no statistically significant variation in observed respiratory health problem between males and females in the study population.

- Analysis of observed health status data shows that older people (above 60 years) have higher respiratory problems.

The table below presents the patterns emerging with regard to various health and environmental conditions in the study area and helps to identify the most and least stressed groups in terms of each parameter.

Table 2B.23 Air pollution and health status results emerging from various data sets[4]

	Reporting of air pollution (QOL survey*)	Ambient air quality	Average exposure	% of people w/ exposure over 150	Reported lower respiratory illness	Pulmonary function test	X- ray (resp infections and TB)
Most stressed	**Cluster II**	**Corridor**	**Corridor**	**Corridor**	**Corridor**	**Corridor**	**Cluster II**
	Cluster III	Cluster II	Cluster II	Cluster III	Cluster II	Cluster II	Cluster III
	Cluster I	Cluster III	Cluster III	Cluster II	Cluster III	Cluster III	Cluster I
		Cluster I	Cluster I	Cluster I	Control	Cluster I	Corridor
Least stressed	Control	Control	Control	Control	Cluster I	Control	Control

* The QOL survey was conducted in Phase II. There was no road corridor in the QOL survey.

Table 2B.23 shows that the Road Corridor is consistently most stressed in terms of air quality (ambient and individual exposure) and most stressed in terms of lower respiratory illness (for self-reported illnesses and those detected through the PFTs). Interestingly, the corridor has not emerged worst off based on the X-rays. It is important to note, however, that X-rays are expected to highlight impacts of long term exposure while PFT measures lung efficiency/ capacity at the time of the test. The road corridor (along with Cluster III) is the youngest area involved with mining/ allied activities. Therefore, even though exposure may be currently the highest, the period of exposure may be the lower than Cluster I and II. This may explain why the Corridor emerges less stressed than other mining Clusters in terms of X-rays.

In the mining region Cluster I emerges the least stressed in terms of air pollution. Current ambient air quality and average exposure are low in Cluster I. Reporting of air pollution in the QOL survey was also lowest in Cluster I. This helps to explain the lower levels of reported and observed respiratory health problems within the population. Other factors that may be influencing relatively better health in Cluster I are better access to health care which emerges in this study and in the QOL survey. Additionally the Phase II QOL survey highlights higher levels of income and consistently higher levels of education in Cluster I which might be having an additional impact on ability to access medical care including private care and on awareness regarding the impacts of air pollution.

Cluster II is second only to the Road Corridor in terms of air pollution levels (ambient and exposure). That Cluster II is worse off compared to III and I also emerges in the QOL survey based on people's own reporting. Looking at respiratory health, both self reported and observed, a clear pattern emerges where Cluster II is consistently worse off or more stressed than Cluster III and Cluster I.

Collectively the results on exposure levels, self-reported and observed health suggest a strong correlation between high levels of exposure to respirable suspended particulate matter and respiratory ill health.

[4] Results from the RSQ have not been included since the analysis from this data is disaggregated for different symptoms.

2C Economic valuation of the cost of ill health

Introduction

This component of the project has focused on developing an econometric model to value the cost of ill health as a result of increased air pollution in mining areas. Previous sections in this chapter have highlighted air pollution exposure levels and respiratory health problems in the study area. This data has been used to estimate the cost of ill health through the model developed.

The focus of this study is on air pollution generated by mining and allied activities. However, in developing countries, a large percentage of households, especially in rural areas, use solid fuels such as wood, coal, dung and agricultural residues for cooking. This results in extremely high levels of indoor air pollutants with consequent high levels of exposure to air pollution which is a confounding factor. This has not been sufficiently reflected in air pollution valuation studies. Pearce (1996) noted that a major weakness of the literature on air pollution damage in developing countries was the focus on outdoor pollution, and the lack of distinction between ambient concentration and exposure.

In their key paper, Harrington and Portney (1987) have developed a health production model, which showed the role of averting and defensive activities. As Freeman (1993) notes, one of the key averting activities is staying indoors on high pollution days. We believe that the Harrington and Portney (1987) model needs to be modified if air pollution is to be valued in a developing country context, particularly in rural areas.

Larson and Rosen (2002) have combined the insights from agricultural household models with the Harrington and Portney (1987) type models. In this component, we develop a model drawing on the Harrington and Portney (1987) model, agricultural household models, and 'Total exposure assessment' (TEA[5]). This has an important consequence (Smith 1993) as the significance of small and local sources, especially indoor sources are accounted for.

We develop an analytical model (discussed in detail in Annexure A) to examine the willingness to pay of a rural household in a developing country. Although we make some simplifying assumptions, the model is in several ways more intricate than the Harrington and Portney (1987) model. Having derived analytical expressions for the willingness to pay, we discuss the role of some features which we have not taken into account in the model to keep it analytically tractable—gender roles in the household, exposure with more than two microenvironments, non-market activities of the household, and whether the household accurately perceives the role of air pollution on health. We also discuss the public good nature of outdoor air pollution and the private good nature of indoor air pollution.

[5] TEA is a branch of environmental health sciences. Using exposure rather than ambient concentrations is the basic principle of TEA.

Results of estimation

Table 2C.1 Regression results for dependent variable respiratory sickdays

	Tobit	xttobit
	resp_sickdays	**resp_sickdays**
cum_exp	2.22E-07	2.22E-07
	(3.73)**	(3.73)**
non_smok	-7.224	-7.224
	(0.98)	(0.98)
male_dum	-7.210	-7.210
	(0.99)	(0.99)
pc_expend	-0.017	-0.017
	(3.27)**	(3.27)**
Constant	-81.725	-81.725
	(7.73)**	(7.73)**
Observations	1170	1170
Number of group(comcode)		277
Absolute value of t statistics in parentheses		
* significant at 5%; ** significant at 1%		

As Table 2C.1 shows, the coefficient of the variable cum_exp (cumulative exposure[6]) is statistically very significant, as is per capita expenditure. In other words, we can reject the null hypothesis that the value of the coefficient of cumulative exposure is zero at a 1% level of significance.

Only per capita expenditure and cumulative expenditure are statistically significant. Hence only the substantial or practical significance of the coefficients of these variables is discussed. The elasticity of respiratory sick-days with respect to cumulative exposure is about 0.35 at the mean of the sample. This implies that a one percent increase in cumulative exposure will lead to a 0.35 percent increase in respiratory sick-days. The elasticity with respect to per capita expenditure is -0.33.

Table 2C.2 Regression results for the dependent variable cumulative exposure

	cum_exp
Ambient	84,028.032
	(9.31)**
Constant	42050546.030
	(12.79)**
Observations	1402
R-squared	0.06
Absolute value of t statistics in parentheses	
* significant at 5%; ** significant at 1%	

[6] Cumulative exposure has been calculated by multiplying level of exposure that individual i faces, with the number of years the individual reported having stayed in the mining area.

Table 2C.3 Regression results for the dependent variable ambient concentration

Cluster	Ambient
I	232.977
	(21.44)**
II	309.412
	(34.49)**
III	227.267
	(24.78)**
Corridor	461.333
	(42.63)**
Constant	71
	(9.38)**
Observations	1410
R-squared	0.59

Absolute value of t statistics in parentheses

* significant at 5%; ** significant at 1%

As Table 2C.3 shows, the coefficient of ambient concentration is statistically significant relative to cumulative exposure.

Table 2C.3 shows that the cluster dummies are statistically significant explanatory variables for the dependent variable ambient concentration. The ambient concentration varies between clusters, and the value of the coefficient indicates the difference between level of that cluster and the control cluster, which is the base. Corridor for instance, had a level of ambient concentration that was about 461 units higher than the control cluster. The Corridor is the highest followed by Cluster II, I and III.

We can then use the information above to value the effect of air pollution:
Value of cumulative exposure due to mining per person =
Loss of wages per person (Rs. per sickday)
× marginal effect of cumulative exposure on respiratory sickdays
× marginal effect of ambient concentration on cumulative exposure
× difference between ambient concentration in mining and control cluster.

Table 2C.4 Monetary loss per person on average assuming a loss in wage of Rs 100/sickday in Rs

Cluster	Loss of wages per person per 3 months (Rs./sickday/ 3 months)	Annual loss of wages per capita (Rs./sickday/ year/person)	Total work force*	Total wage loss per year (Rs./year)
I	62	248	16,133	4,000,984
II	83	332	17,702	5,877,064
III	61	244	10,689	2,608,116
Corridor	124	496	8,105	4,020,080
Total				**16,506,244**

* Census 2001

The table above tells us the quarterly per capita loss of wages in each of the three clusters and the road corridor, due to sick-days (as calculated from the model and based on the 3-monthly recall period in the survey). We can then calculate the annual per capita loss of wages due to sick days. Additionally, we multiply the size of the work force in the clusters and the corridor with their respective annual per capita wage loss due to sick-days to get the total wage loss for the mining region.

We see that the annual per capita wage loss is highest in the road corridor (Rs. 496 per capita/year) followed by Cluster II (Rs. 332 per capita/year) and then Clusters I and III with similar levels of loss.

Looking at the total annual wage loss to the mining regions and the road corridor together is Rs. 16,506,244.

Similarly, we can estimate the economic value of increased doctors' visits due to air pollution arising from mining activities.

Table 2C.5 Regression results for dependent variable doctor visits

	Tobit	xttobit
	Docvisitr	docvisitr
cum_exp	0.000000208	0.000000208
	(3.18)**	(3.18)**
non_smok	33	33
	(4.04)**	(4.04)**
male_dum	-2.6	-2.6
	(0.33)	(0.33)
pc_expend	-0.009	-0.009
	(1.99)*	(1.99)*
Constant	-114	-114
	(10.41)**	(10.41)**
Observations	1277	1277
Number of group(comcode)		280
Absolute value of t statistics in parentheses		
* significant at 5%; ** significant at 1%		

Cumulative exposure is a statistically significant explanatory variable for the number of doctor visits. The elasticity of doctor visits with respect to cumulative exposure is 0.24. This means with a one percent increase in cumulative exposure, will lead to a 0.24% increase in doctor's visits. The elasticity of doctor visits with respect to per capita expenditure is -0.12.

Ideally we would like to have had data on visits to the doctor only on account of respiratory problems. It was difficult for respondents to recall how much they spent for which kind of illness. Therefore we regressed doctor visits on cumulative exposure to air pollution, controlling for other variables, and used the coefficient of cumulative exposure to air pollution. It is reasonable to suppose that this would primarily capture effects of air pollution

on doctor visits. (Please see the step by step equations with the tables of regressions in Annexure A).

Table 2C.6 Average monetary expense per person, assuming expense of Rs. 100 per doctors visit

Cluster	3-monthly monetary expense per person, on average, due to a doctor's visit (Rs./person/3-months)	Annual per capita monetary expense due to doctor's visits (Rs./person/year)	Total population*	Total expense due to doctor's visits per year (Rs./year)
I	81	324	42,780	13,860,720
II	107	428	44,711	19,136,308
III	79	316	25,421	8,033,036
Corridor	160	640	21,407	13,700,480
Total				**54,730,544**

* Census 2001

The table above shows the quarterly per capita expense on doctor's visits, (as calculated from the model and based on the 3-monthly recall period in the survey). Using these figures we are able to arrive at the annual per capita out-of-pocket expense. Multiplying these figures with the total population, we can get estimates of the annual expenses borne by each of the Clusters and the Road corridor in terms of doctors visits.

Once again we see that the annual per capita expense due to doctor's visits is highest in the road corridor at Rs. 640, followed by Cluster II (Rs. 428) and then Clusters I and III.

Looking at the total annual expense to the mining regions and the Road corridor together is Rs. 54,730,544.

Since the externalities from mining are a public good, we can add up the money values over the population of the cluster to get a sense of aggregate damages via air pollution caused by mining over time. We see that the total annual cost of ill-health due to exposure to air pollution in the mining regions of Goa is Rs. 71,236,788 (USD$ 1,548,625.83).

Highlights

- Model used incorporates total exposure assessment and agricultural model to estimate cost of ill health.
- On average (Clusters and Corridor) estimate of wages lost per person (in the work force) due to respiratory sick days is Rs. 330 per year.
- On average (Clusters and Corridor) annual expenses due to doctors visits is Rs. 427 per person
- Total annual cost of ill health due to doctors visits and wages lost for the mining region is Rs. 71,236,788 (US $ 1,548,626)

2D Health care services

This component of the study focuses on an assessment of health care services in the study area. As communities in the mining regions face a variety of environmental stressors (especially poor air quality) that have an impact on health, the availability of health care services in the region plays a crucial role in improving health outcomes in the region. This component of the study has the following objectives:

- Assess availability of health care services in the Mining Clusters and the Road corridor area in terms of:

  - Medical manpower available
  - General medical facilities available
  - Specific respiratory health care facilities available

- Identify what medical care facilities are provided by mining companies
- Assess people's perceptions regarding public and private services
- Assess usage of public and private health care within the community

The state health system is classified into three tiers, namely primary, secondary and tertiary where the level of care becomes more advanced or specialised moving from the primary to the tertiary level. This structure of the health services is uniform throughout the country.

The primary care level is further broken down into three tiers comprising of sub-centres (SC) at the lowest level (population served 5000), followed by primary health centres (PHC) (population served 30,000) and community health centres (CHC) (population served 120,000). Together these facilities provide basic medical care in rural areas.

The secondary level of care includes more advanced services provided through district hospitals. The tertiary level of care provides the most specialised care and is delivered through the Goa Medical College Hospital located in the capital city. For a detailed map of health care system and services in the state see Annexure A.

At the primary level there is a greater emphasis on preventive care while at the tertiary level the focus is more on curative care. Preventive care at the primary level is delivered through the national health programmes focusing on family planning, antenatal care, child health, immunisation, education outreach regarding sanitation, diarrhoea, worm infestation etc. Additionally, there is a focus on early detection of communicable diseases such as malaria etc. through mass or family screenings and provision of preventive medicines. Another important aspect of preventive care at the primary level is home, nursery and school visits by multipurpose health workers with a special thrust on family health and child development. In addition to preventive care, the Primary Health Centres (PHCs) and Community Health Centres (CHCs) provide basic curative care. More specialised care is accessed through the referral system.

Health care facilities in the study area

The study area consisting of the three Clusters and the Road Corridor includes mostly rural areas and four small towns (one in each Cluster and one in the Road Corridor). Thus, all the government health care facilities present in the study area belong to the primary level of care.

Before presenting the data about the availability of care, however, is it important to understand the spatial nature of the study area. Cluster I and Cluster II are adjacent to each other and fall mostly into Bicholim taluka with a few villages in Cluster II falling into Sattari taluka. When presenting data on health care services by Cluster we have presented information about the Primary or Community Health Centre in the main town in each cluster. However as these Clusters are next to each other it is important to remember that people in Cluster I may be visiting the health centre in Cluster II and vice-versa.

The same is true for Cluster III and the Road Corridor. The Road Corridor, Curchorem (in Quepem Taluka), is an urbanised town with a Community Health Centre. Curchorem is adjacent to Sanguem Taluka (Cluster III). Thus, many people in Sanguem visit the Curchorem health centre. In general, there is good bus connectivity to urban areas across the state and as Goa is a small state even rural communities have relatively easy access to big cities where full-fledged specialised health services are available. Table 2D.1, below provides basic information on population served by each health centre in the study area.

Table 2D.1 Population served by public health centres in the study area

Study area	Health centres	Total population served by health centres (2001)
Cluster I	Bicholim PHC	51292
Cluster II	Sanquelim PHC	39115
Cluster III	Sanguem PHC	61064
Road corridor	Curchorem CHC	51444

Census of Goa 2001 for total population / talukas

The tables below present statistics on the number of government health care facilities and health care workers in the study area relative to the government norms.

Public health centres

Table 2D.2 Number of public health care institutions serving the population

	Comm. Health Cent.	Primary Health Cent.	Sub-centre	RMD	Population
NORM:	*1 CHC: 120000*	*1 PHC: 30000*	*1 SC: 5000*		
Bicholim		1	8	1	51292
Sanquelim		1	7	2	39115
Sanguem		**1**	11	2	61064
Curchorem	1		8	1	51444

Numbers in bold indicate population served exceeds norms

Source. Health Profile 2005, Health Intelligence Bureau, Directorate of Health Services, Panaji Goa.

Table 2D.2 (above) shows that the population being served per primary health centre in Cluster I (Bicholim) and Cluster III (Sanguem) are higher than the national norms. In cases where the population served is low or within norms, at times the area covered is very vast so accessibility becomes difficult. This was observed mostly in Cluster III (Sanguem) where villages are remote and the transport network is not as well developed. In some cases people find it easier to get to the nearest town for health care than to their nearest sub-centre which may be located in the interiors of another village. Thus, people from the study area are very likely accessing some of the larger hospitals in near by towns (Mapuca, Ponda, Margao etc.). People also use private health care facilities across the region.

Public and private hospitals

Table 2D.3 Public and private hospitals across mining region

	No. of hospitals	No. of beds	Population
		Bed (Norm: 1:1000)	
Bicholim (Clust. I)	7	140	51292
Sanquelim (Clust. II)	2	**10**	39115
Sanguem (Clust. III)	2	80	61064
Quepem (Curchorem) (Road Corridor)	7	150	51444

Numbers in **bold** indicate population served exceeds norms

Source. Directory of hospitals in Goa 2005, Health Intelligence Bureau, Directorate of Health Services, Panaji Goa.

Table 2D.3 above shows the number of hospitals and beds relative to population of the study area. It shows that there are fewer beds in Sanquelim relative to other areas. The number of people served per bed is much higher than the norm of 1 bed per 1000 population in Sanquelim. It is important to note that these figures include beds provided by private health facilities which are not provided free of cost.

Health care manpower

During focus group discussions, several people in the study area complained about lack of staff (doctors, health workers, nurses and technicians) in the sub-centres and other facilities in the study area. Additionally, during field visits it was not uncommon to find two sub-centres manned by one health worker because of lack of staff. At some Primary Health Centres (PHCs) diagnostic facilities like X-rays and pulmonary function tests were not available because technicians to run the machines were unavailable. Table 2D.4 (below) provides information on the health care manpower in the government health facilities.

Table 2D.4 Public health manpower serving the population

	Doctors	Nurses	Multipurpose Health worker (Female)	Multipurpose Health worker (Male)	Pharmacists	Technicians	Population
Norms worker: pop	*1 dr: 3500*	*1 nurse: 5000*	*1 MPHW: 5000*		*1 pharm: 10,000*	*1 lab tech: 10,000*	
Bicholim	**5 (1)**	9	12 **(4)**	4	**1**	**1**	51292
Sanquelim	**5 (1)**	**5**	6 **(1)**	5	**1**	**1**	39115
Sanguem	**7**	**5**	11	11	**1**	**1**	61064
Curchorem	**7 (3)**	14	15	15	**1**	**3**	51444

(n) = number in parentheses indicate the number of posts sanctioned but vacant

Numbers in **bold** indicate population served exceeds norms

Source. Citizens Charter 2000, Health Intelligence Bureau, Directorate of Health Services, Panaji Goa.

Table 2D.4 shows the total number of staff positions sanctioned for each health centre in the study area. The numbers in brackets indicate the number of the sanctioned positions that were vacant at the time of visiting the centre. For example, of the five doctor posts in Bicholim one is vacant so actually there are only four doctors serving the population. The table shows that the number of medical staff sanctioned to serve the mining areas is low relative to government norms. The number of doctors posts sanctioned is very low throughout the study area and of the posts sanctioned several are not filled. In Clusters I, II and III there are no specialist doctors serving the health centres as PHCs are not required to have specialists. In the Road Corridor the CHC is supposed to have four specialist but there are only general practitioners serving the health centre. Thus, people across the study area have to visit district hospitals or use private care.

The number of nurses is particularly low in Sanquelim (Cluster II) and Sanguem (Cluster III). The number of multi-purpose health worker posts in Bicholim (Cluster I) and Sanquelim (Cluster II) is sufficient but some posts are not filled. When staff positions are vacant the female MPHWs are expected to man two health centres which makes it difficult for them to carry out their duties. Additionally, the number of pharmacies and technicians (especially an x-ray technician in Sanquelim) is very low relative to the population.

Respiratory care facilities in the public health centres

In keeping with the studies focus on respiratory health the following tables provide an overview of respiratory care measures that are available in the study area for treating simple respiratory illness. They are divided into diagnostic, mechanical and medical management services.

Table 2D.5 Diagnostic services

	Pulm. Funct.Test	Sputum	Chest x-ray	Blood analysis
Bicholim	X	√	X	√
Sanquelim	X	√	√	√
Sanguem	X	√	X	√
Curchorem	X	√	√	√

√ = available, X= not available

Table 2D.5 (above) shows that there is no chest x-ray facility in the Bicholim health centre. The x-ray facility at the Sanquelim Primary Health Centre is available only two days a week. Importantly, there is no radiologist at the Sanquelim centre so all X-rays have to be sent to the district hospital to be analysed. There is no X-ray facility at the Sanguem health centre and there are no facilities for pulmonary function tests in the study area. Simple sputum and blood tests are available in all the centres.

Table 2D.6 Respiratory management measures

	Oxygen	Nebuliser	Suction	Medications
Bicholim	√	√	√	√
Sanquelim	√	√	√	√
Sanguem	√	√	√	√
Curchorem	√	√	√	√

√ = available

Basic services like oxygen, steam inhalation, and nebulisation are available throughout the study area as shown in Table 2D.6 (above). Respiratory medicines are available at all health centres in the study area and are provided free of cost. Additionally, simple medications (eg. Cough syrups, decongestants, pain killers, de-worming medication, antacids) are also provided free of cost.

In general, only basic respiratory care facilities are provided in the primary health centres. For other services the people have to access the private health sector, dispensaries run by mining companies (only curative services) in few villages or district centres in the region. For further diagnostic tests, specialized doctors, sophisticated facilities and services they have to follow the referral system and access the state hospitals.

Table 2D.7 (below) provides a summary of hospital care services available in the study area.

Table 2D.7 Other public health care services

	Ambulance	Hospitalization	Out patient dept.	Emergency care (ambu bag, med...)
Bicholim	√	√	√	√
Sanquelim	√	√	√	√
Sanguem	√	√	√	√
Curchorem	√	√	√	√

√ = available

Basic health care services for hospitalisation and acute/ emergency medical management are available in the public health care system for minor or uncomplicated occupational trauma or injuries (as shown in the table above). For further management (intensive care unit, trauma care, respirator) people or workers are referred to specialized hospitals, which are not in the mining areas. It is worth noting that there is a lack of doctors with specialised training in respiratory medical care and occupational hazards and safety measures at health centres in the mining regions.

Private health care services

In addition to government health care services, there is a range of private facilities in the study area. Table 2D.8 (below) summarises private health care facilities in the study area.

Table 2D.8 Private health care facilities in the mining areas

Area	Allopathic clinics	Indigenous doctors	Dentists	Hospitals	Diagnostic Centres	Pharmacies
Bicholim	35	2 ayurvedic, 1 homeopathy	4	6	4	9-10
Sanquelim	15	2 ayurvedic	1	1	2	2-3
Sanguem	10	1 homeopathy	0	0	1	1
Curchorem	30	1 homeopathy	2	7	5	5-6

In general there are several private dispensaries in Bicholim and Curchorem probably owing to the fact that these are urban centres. Similarly, the number of hospitals, diagnostic centres and pharmacies in Bicholim and Curchorem are high but very low in Sanquelim and Sanguem.

While private health care providers outweigh the public system in terms of provision of infrastructure, these providers are concentrated mostly in Bicholim town and Curchorem town. There are relatively few private care providers in rural parts of the study area especially the interiors of Sanguem. Importantly, private care is expensive making it inaccessible for people in low income groups.

In addition to allopathic medical care, during focus group discussions people reported preparing and using home remedies for simple ailments as they are cheap and generally do not have side effects. Participants in focus group discussions also reported accessing traditional ayurvedic and homeopathy doctors in the study area for minor and chronic illnesses.

Health care provisions by the mining company

This section provides more detailed information on health care services provided through companies. These health care facilities can be classified as provisions for mine workers and provisions for the community.

- **Provisions for mine workers**

Mining companies are obliged to provide health care services to mine workers as stipulated by a variety of legislative acts. The Iron Ore Mines, Manganese Ore Mines and Chrome Ore Mines Labour Welfare Cess (Amendment) Act, 1982 mandates that a one rupee cess be collected per tonne of iron ore that is either exported or used for local consumption. The use of this cess fund is stipulated by the Iron Ore Mines, Manganese Ore Mines and Chrome Ore Mines Labour Welfare Fund (Amendment) Act, 1982. These funds are to be used for improvement of public health and sanitation facilities; prevention of disease and improvement of housing; educational, recreational and transportation facilities and social security benefits for Iron ore mine workers. These welfare facilities are extended to both

workers and contracted employees. Mining companies in Goa contribute to this welfare cess and also avail of funds from the cess to provide medical facilities to workers.

Free consultation facility at mine dispensaries: The Mines Safety Act of 1952, mandates that a first aid room stocked with medicines, equipment and medical and nursing staff should be available in case there are more than 150 workers (Section 22, (1-4), Mines Act, 1952). In keeping with this regulation, several companies have set up dispensaries attached to their mine sites and provide free medical consultation to workers. Some companies extend services to workers' family members. Interestingly, several companies have availed of a grant from the welfare cess fund (explained above) to set up these dispensaries.

Emergency facilities: The Mines Act of 1952 (Section, 22, (5)) also mandates that an ambulance facility be available for emergency situations. This facility is also commonly provided by mining companies in Goa and here too companies have availed of a grant in aid from the welfare cess fund to purchase ambulances. There are instances where the ambulance facilities have been extended to the community as well.

Regular health check-ups: Pre-employment and periodic health check up for mines workers is mandated by the Mines Safety Act, 1952. There are guidelines to cover the different parameters that need to be examined and recently spirometry has been included as one of the parameters. Several of the larger companies in Goa are following these guidelines.

Medical reimbursement: Reimbursement of medical costs for workers is made available through the Cess Welfare Fund for mine workers (explained above). Through this provision medical aid is provided to workers for chronic illness such as tuberculosis, heart diseases, kidney transplant and cancer. Medical expenses ranging between Rs. 100,000 to Rs. 200,000 for the above illnesses is covered and in some cases, a subsistence allowance is paid for the attendant of the patient, travel cost and reservation of beds (at government and recognized private hospitals). Additionally, the Workman Compensation Act, 1923, under the labour department and the Mines Safety Act ensures that workers are compensated in case of accidents at the workplace. In Goa mine workers were provided free consultation and hospitalization facilities through a 150 bedded hospital (Central Hospital) and a mobile dispensary. This facility was made available through the welfare cess, however these facilities are currently not available because the hospital has closed down. A proposal for the State government to take over this hospital has been floated and is under consideration.

In addition to insurance provided by the state, some of the larger companies in Goa provide reimbursement through group insurance policies purchased by the company. The terms of coverage vary from one company to another. Some mining companies also pay their workers an annual medical allowance for the family.

❖ **Provisions for the community**

The Minerals Foundation (MF) of Goa, a trust fund set up by the mining industry in Goa, provides some community health facilities from time to time[7]. Health interventions taken up target a wide sector of the local community including women, children and the aged residing in the mining region. The following is a list of MF's initiatives:

1. **Health camps:** health check-up, blood group testing camps in schools and villages
2. **Surgeries for cataract** through the project Drushti wherein they have covered 111 patients between 2004-2005.
3. **Medical consultation for the aged through a mobile dispensary for the aged** in collaboration with Help Age, India which covers around 8 villages in the mining region (out of approximately 54 mining villages).
4. **Distribution of nutritional supplement** for TB patients in the mining regions.
5. **Weekly medical consultation facility in association with** Matruchaya seva at Savordem and a **help desk facility at the GMC.**
6. **Provision of financial assistance for treatment** for illness that is often not covered through medical insurance such as travel, post-operative care and expenses of the attendant accompanying patients.

People's perceptions of health care services in the study area

Through focus group discussions with men and women in the local community people's perceptions of health care services were recorded. The table below summarises people's perceptions of public health services in each of the three mining Clusters and the Road Corridor.

Cluster I	Generally happy with government health care services Use government centres for all kinds of illnesses, facilities and hospitalisation
Cluster II	Long waiting times are inconvenient At times medical treatment is ineffective For some people access in terms of distance and connectivity is difficult Poor/unfriendly attitude of staff
Cluster III	Not enough health centres in the rural areas. Those that exist are very far and inaccessible to many. Waiting times at government health centres are too long Medicines that are supposed to be available free are not available Poor/unfriendly attitude of staff
Road Corridor	More waiting time on certain days as the centre caters to a large population and has other facilities Often lack of working equipment or doctors Acquaintance with the doctor ensures better treatment People prefer going to the government centres for vaccinations and deliveries Ambulance is not always available during emergencies or at night Poor/unfriendly attitude of staff

[7] The minerals foundation is the outcome of a corporate social initiative, which came into being in 2000.

Utilisation of health care services

During focus group discussion people showed a preference for private health care facilities. The (Governance) survey conducted in this study has reinforced this finding. In all 442 households were surveyed, spread across the study area. Respondent were asked which health care facilities i.e. government /private they had availed.

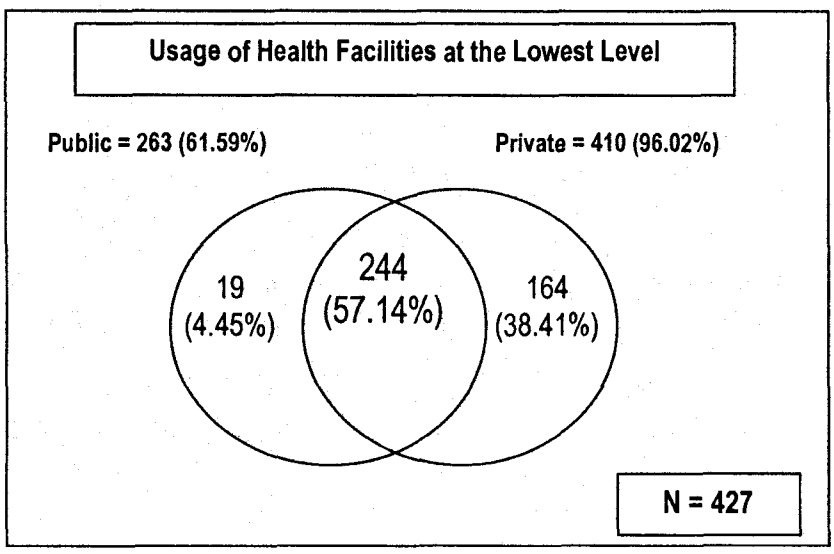


Figure 2D.1 Usage of private/ public health facilities at the lowest level

When asked this question about usage of private and public facilities at the lowest level of care (sub-centres, rural medical dispensaries, private clinics), of a total 427 respondents who answered the question, 96 % reported using private health care facilities and 62% reported using public facilities (Figure 2D. 1). The percentage does not sum to hundred percent as 57 percent of the respondents use both facilities. Thirty-eight percent respondents reported using only private facilities and only 4 percent reported using government facilities exclusively. One possible explanation could be that the sub-centres are open for consultation for half a day on a weekly basis and in some cases they are closed due to lack of staff. The rural medical dispensaries on the other hand generally have consultation facility throughout the week however there are few rural medical dispensaries (only 5) in the study area. The consultation timings at these facilities coincide with the working hours as opposed to private facilities, which are open beyond working hours. Additionally, it is possible that respondents underreported use of government facilities as using government health services reflects a poor economic status.

Figure 2D.2 (below) depicts the usage of health care services at a middle level (Primary/ Community Heath Centres/ private nursing homes/ hospitals). Here too use of private facilities (87%) is much higher than public (68%). When these figures are compared against those for usage at the lowest level of health care it shows that there is a 9 percent increase in usage of government health care services. This could be because Primary and Community health centres include hospitalisation facilities, which are free as opposed to the private centres where hospitalization is expensive. Even though outpatient care is expensive at private facilities (relative to public which is free) the amount of money involved is probably

affordable for many people in the study area. On the other hand, for hospitalisation or more complex treatments, which involve large sums of money at private facilities, a greater percentage of respondents may prefer to use the government services.

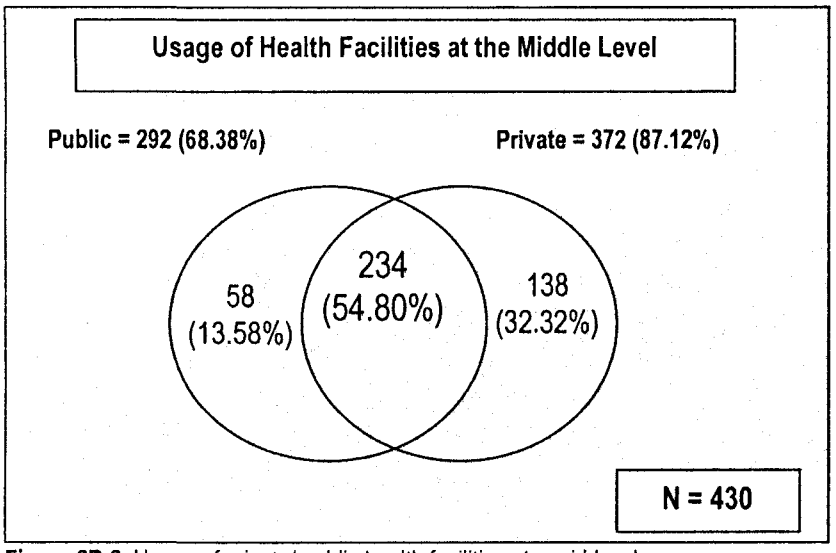


Figure 2D.2 Usage of private/ public health facilities at a mid-level

The data presented in this section suggests that the structure of state health care services and the level of care to be provided at the regional level is adequate. However, all parts of the study area there is a shortage of staff and facilities relative to national norms. Additionally, state health care services have not kept up with population growth in the mining regions. While private facilities make up for the shortfall in public services, their facilities are expensive and therefore not accessible to low income groups. Importantly, private care is focused on curative services while public health sector provides a range of preventive care facilities as well. For this reason where public facilities are poor/inadequate, private care cannot be seen as an adequate alternative.

Highlights

- The number of people being served by the Primary Health Centre is high relative to the norms in most parts of the study area
- The number of staff serving the mining areas is low, specifically doctors
- Vacant posts for doctors and health workers adds further stress on the system
- In parts of the study area there are no No X-ray and PFT equipments and no technicians and trained medical staff to interpret the results in the government Primary health centre
- While a large number of private medical clinics, hospitals, diagnostic centres and dentists and pharmacies exist in urban areas, rural areas are served mostly by the public health system
- Fair number of mining dispensaries and doctors at and near the mine sites for curative care
- Local community members are dissatisfied with public health care services in terms of:

  - Waiting time for doctors visits
  - Attitude of staff
  - Distance of health care centres from villages
  - Lack of equipment/ services
- Most people in the study area are using a mix of public and private health care facilities.
- Percentage of people using only public facilities is low (between 4% and 13%).
- Percentage of people using only private facilities is high (between 32%- 38%)

Conclusions

This component of the research highlights the impacts of air pollution on health. The data shows that ambient and exposure levels are high in the mining Clusters and the Corridor compared to the Control area. Importantly, respiratory ill health reported and observed in the study follow a similar pattern. The relative risk of developing health problems in mining Clusters and the Corridor is high relative to the Control area. The study also shows that the per capita cost of ill health based on wages lost and expenses incurred as a result of doctors visits is high in the mining Clusters and highest in the Road corridor area.

As access to health care is an important determinant of health this study has also focused on health care services in the region. Cutting across public and private care, one finds a large number of health care centres available in urban parts of the mining regions but fewer facilities in remote rural areas. While Goa is a small and relatively well-connected state where it is possible to access government health care centres in other areas, this imposes an extra cost on communities in remote areas. Additionally, data shows a lack of medial staff and facilities at government health centres. Thus, even where there are centres care may be inadequate.

These shortcoming have been perceived and reported by community members through focus group discussions. Additionally, the fact that a large percentage of people have reported using private facilities (as opposed to government centres which are free) suggests the cost of externalities of mining have been passed on the local community rather than the state.

Even though medical professionals and staff at the various health centres are aware of the increased respiratory problems in the area, there has been no special attention to chronic respiratory problems or enhancement of respiratory care facilities to cater to the needs of mining communities.

In order to cater to the needs of local communities, in all three mining Clusters and the Road corridor, existing health care facilities need to be enhanced in terms of general care and respiratory health care and in some areas new health centres are required to cater to the growing population.

Chapter 3: Land

This chapter, focusing on land resources in the mining regions is divided into two sections. Section 3A deals with the impacts of mining on agricultural land resources in the region and further on the community. Additionally, it includes an assessment of responses to changes in land and employment from various stakeholders.

Section 3B addresses the issue of metal up-take in fruit crops grown on dumps as part of land remediation measures.

3A Impact of mining on agricultural land and employment

Introduction

Mining activities have a profound localised impact on land resources, which in turn impact local communities in the region. These impacts occur in two ways. When new mine leases are issued large tracts of land belonging to individuals and communities are absorbed into the lease. At this time people not only loose the land on which they live but also land which forms the basis of their livelihoods. Once mining operations have begun, land around mines can be affected by mining operations through run-off from overburden dumps which is the focus of this component of the project.

The main objectives of this component of the study are as follows:

- Identify how mining activities affect land resources in the region
- Identify how this has affected livelihood opportunities in the region, especially for women
- Identify responses to land related problems by key agents in the region (including compensation)

Methodology

Focus group discussions

A total of three focus group discussions (one in each of the mining clusters) were conducted in villages across the study area with men and women farmers.

Cluster I: Soliyem, Sonus 8 women, mixed age groups, mixed land holdings, two agricultural labourers Cluster II: Cudnem 9 men, mixed land holding sizes, mixed age groups Cluster III: Codli 15 men, mixed age groups, mixed land holding sizes

The aim of these focus group discussions was to identify;

- Changes in cropping patterns over the years
- How mining had affected agricultural land in the region

- The availability of compensation
- The role of farmers groups

Interviews and discussions

Interviews and discussions were conducted with the Zonal Agricultral Officers, Deputy Collectors and mining company representatives. These discussions focused on the state of agriculture in the mining regions and procedures for compensation payments. Additionally, discussions with representatives from the Indian Bureau of Mines, the State pollution Control Board, Water Resources Department were taken up regarding their functions and their role in the mining region.

Interaction with farmers

In addition to more formal research methods used such as focus group discussions and interviews, the capacity building component for farmers in this project presented ample opportunities to interact with local farmers groups. Through almost continuous interaction with farmers for small programmes, meetings, transect walks etc. researchers have come to know the field intimately and begun to understand with more clarity how exactly agriculture is affected by mining. In addition to group strengthening exercises, interactions with farmers have included helping farmers deal with government officials and company representatives in terms of whom to approach, how to put forth their case etc. This work has helped us to understand the vast network of government bodies that have an impact on agriculture and the gaps in government initiatives be they supportive or regulatory. While we adopted focus group meetings as one of the methodologies to explore issues, the process of interaction over time and simply maintaining notes has rewarded us with a wealth of detailed knowledge on the impacts of mining on the land and on governance and decision making in this context.

Additionally, interaction with women's self-help groups has also provided a lot of information about agriculture as many women in these groups are farmers who belong to agricultural households.

This component of the research has been participatory where a process of mutual learning by researchers and farmers has evolved over time.

Results

Impact of mining on land

In the iron ore mining areas of Goa the ore to overburden ratio is roughly 1:3. Thus, for every ton of ore excavated three tons of overburden material is generated. This material is piled into steep and high dumps. Poor dump management coupled with the heavy monsoons experienced in Goa results in large-scale soil erosion from these dumps. This silt-laden water enters the drainage network and also enters adjacent low-lying paddy fields resulting in the accumulation of silt in fields and water bodies. As mining in Goa is located in rural areas where agriculture is a primary source of income, changes on the land have a profound impact on livelihoods and on human well-being.

Men and women in the study area reported changes in cropping patterns over the past several years. This includes a shift from crop rotation to growing only rice and the use of chemical fertilisers. No farmers (men or women) reported using pesticides. Many farmers

have stopped growing traditional varieties and have shifted to high yielding hybrids such as Jyoti and Jaya. Additionally, among the larger farmers it has become common to use a power tiller for land preparation. However, these changes reported by farmers are not limited to the study area but are widespread across Goa. Farmers also reported a variety of changes in the conditions of agricultural land as a result of poorly managed overburden dumps.

According to farmers, the accumulation of silt in water bodies and in fields is the root cause of problems in the agricultural system. The accumulation of silt over a period of years has several impacts, namely:

Lowered soil fertility

The silt accumulated on the land, which may be as deep as 80 cm on average, has little or no organic matter and has low fertility. Due to low soil fertility, crop yields begin to drop over time. To some extent, this problem can be addressed by increasing the organic matter content in the silt layer and by applying large quantities of chemical fertilisers. However, these measures significantly increase the cost of the crop.

Reduced water-holding capacity of water bodies

For paddy crops grown during the monsoon under normal conditions, the fields are flooded in the early part of the monsoon, which is when the seeds germinate. After a period of time the fields are drained by channelling water from the fields back into rivers or streams. Due to heavy silting, the river and stream beds rise, reducing their water-holding capacity and causing an overflow. Thus, the water in the fields cannot be channelled back into the drainage network leaving the fields waterlogged for long periods of time. As a result, the germinated seeds begin to rot and the crop is destroyed.

Change in land contour

Land contours play a very important role in drainage and irrigation of fields. In order to properly regulate the amount of water in the fields a network of narrow channels needs to be maintained across a level surface so that water can flow effectively. If the fields are not levelled water logging tends to occur in patches the resulting in the destruction of the crop. Additionally, during the winter crop the traditional irrigation technique of channelling water from the streams into the fields by gravity is not possible due to changes in land contours. While this problem can be overcome by using a pump set it further drives up farmers' expenses.

Maintaining land contours in areas that are silted year upon year requires intensive land preparation to even out the level of the fields. This requires additional labour which is expensive. In some areas farmers have attempted to manually remove some of the silt that has accumulated. This is obviously very labour intensive and the problem of where to dump the silt has not been resolved. Some farmers have used it to strengthen bunds running along the fields or they have created small mounds at intervals and tried to plant trees on them. Given the large volumes of silt that have accumulated over the years, these measures are inadequate and piecemeal. Farmers have expressed irritation, anger and helplessness at the fact that this needs to be done every year because the dumps have not been managed and stabilised.

Lack of water

Due to silting of water bodies the volume of water flowing through perennial surface water streams has diminished significantly creating a shortage of water in the dry, winter season when irrigation is necessary. In such cases some farmers have stopped growing the winter crop.

Another source of water for irrigation were small ponds or springs that were perennial. As a result of mine pits being very deep (several meters below sea level) the water tables in the area surrounding the mine have dropped and several groundwater sources, including ponds and springs have dried up.

While some of these problems can be overcome by increasing inputs (more intensive application of fertilisers, use of a pump set, more intensive land preparation using a power tiller) these technical fixes also significantly raise the cost of production. However, farmers felt that this was not an attractive option as paddy is not a very lucrative crop and it is usually grown for self-consumption. Under these conditions farmers reported finding it cheaper to buy rice from the market than to grow it.

In several parts of the study area, plots of land are owned/managed by large numbers of farmers. For instance, in one of the villages in Cluster I, one plot of 19 hectares is owned by 70 farmers. Maintenance of the land is normally taken up collectively, eg. building and maintaining of canals for irrigation, maintaining of bunds along the edge of water bodies, sowing, transplanting, harvesting etc.) As more and more farmers stop farming a critical point is reached when those who are left cannot continue farming because they are unable to maintain the land by themselves. Thus, those who wish to continue farming at times have no choice but to give up farming and with time the system begins to collapse.

This domino affect plays out not only within each plot of land but also at a watershed level. As large groups of farmers opt out of the system, the volume of water being carried in the rivers and streams becomes increasingly unpredictable. This begins to have an impact on farmers upstream and downstream. Thus poorly managed dumps in the upstream reaches of the watershed have wide-reaching impact on water-bodies and land through the entire micro-watershed in which they are located. As a result, agriculture has become an unattractive option for the following reasons:

- Innovation with more lucrative cash crops is difficult because the basic prerequisites, namely a steady supply of water and good quality soil are lacking. Currently there is too much uncertainty in the system.
- Farmers feel frustrated by the fact that several remediation measures have to be taken every year as the flow of silt from the dumps is not contained.
- Compensation is available. It is often financially a more sensible option and also an easier option than farming.
- As some peoples' daily needs are met through alternative jobs (mining and others), the need to continue agriculture for sustenance has decreased over time.

Agricultural employment

The impacts of mining on land have undoubtedly had an impact on livelihoods of agricultural households in the study area. As agriculture has gone into decline with increasing numbers of people choosing not to farm or unable to farm, the amount of work available for local men and women has decreased. While mining and allied activities have provided employment opportunities to men in the study area there are almost no women working in mining and allied activities.

An agriculture gender map is used to estimate employment opportunities lost by men and women in the mining region. In order to identify how many days men and women spend on each agricultural task a small questionnaire was canvassed in five villages among 50 farmers who have agricultural land and are still actively cultivating. Of the five villages, two belong to the study area (Sirigao and Codli) and three are adjacent to the study area (Karapur, Sarvona, Kudchire). These adjacent villages were chosen in order to assess the time spent on agricultural tasks in geographically similar regions but where there is no additional stress on agriculture as a result of mining. Those participating in the study were classified into two groups, namely farmers with small land holdings (less than 1 acre) and farmers with large land holdings (one acre and above). The results of this exercise are tabulated below.

Table 3A.1 Employment generation from single paddy crop

Agricultural activities	Employment generation			
	Person days per 1 acre land (small farmers)		*Person days per 1 acre land (moderate/big farmers)*	
	Male	*Female*	*Male*	*Female*
Land preparation	7	6	2	1
Ploughing	15	1	2	1
Seed selection			1	1
Sowing	4	2	1	1
Transplanting	6	24	2	20
Weeding	1	30	1	8
Applying organic manure	3	2	1	1
Preparing green manure	1	2	0	0
Harvesting	4	18	2	13
Post-harvest	4	2	0	0
Threshing	22	4	7	1
Winnowing	10	5	4	1
Milling	3	2	1	1
Boiling/Drying	1	9	0	2
Market selling	–	–	–	–
Storage	3	2	1	1
Bunding/Fencing	4	4	2	1
Total	**88**	**113**	**27**	**53**
	Total: 201 days		**Total: 80 days**	

The results reveal that farmers who have less than one acre of land generate about 201 person working days per acre of land per paddy crop. Out of this 56% or 113 days are women working days. Meanwhile employment generation from the larger landholdings is much less, i.e. 80 person days of work per acre of land are generated due to mechanization of activities. Of this total, 66% or 53 days are women working days lost. These results are only for one crop, but when we consider a second crop, which is common in some areas where water is available, the number of work days lost increases even further.

According to a previous study (TERI 1997) the change in area under wet land agriculture between 1988 and 1997 in Cluster I and III of the study area is 421 hectares (1040 acres)[1]. If we use this figure of 421 hectares (1040 acres) converted in Cluster I and III to arrive at a rough of estimate total work opportunity lost, (with assumption that 17% of land belongs to farmers having less than 1 acre of land (Statistical Handbook of Goa 2001), we find that for a single crop, over 104,600 work-days are lost due to the impact of mining on agricultural land. Of this, about 65,700 are female work days and about 38,800 are male work days. The same TERI study (1997) estimates that 15% of the total area in Cluster I and 30% of the total area in Cluster III are irrigated. Thus, we assume that of the total land converted to mining 229 acres would have been planted with a second crop. Thus the total number of work days lost increases to 127,000 of which 80,000 are women days lost and 47,000 are men days lost. This calculation shows that women have been affected more in terms of lost livelihood opportunities than men. See Table 3A.2 below.

Table 3A.2 Total loss of work days per year in agriculture due to mining

Land details	Total land in acres	Male days	Female days	Total
Small holdings (< 1 acre)	177	15576	20001	35577
Large holdings (≥1 acre)	863	23301	45739	69040
Total from first crop	1040	38877	65740	104617
Total from second crop	229	8562	14477	23039
Total	1269	47439	80217	127656

While this is an estimate of work days lost for paddy cultivation, it does not include work days lost for cultivation of pulses which would significantly increase the number of days lost. (Land area without irrigation is used for the cultivation of pulses in the dry (winter) season.) Additionally, if data on land area lost to mining in Cluster II were available we would expect a further increase in the total work days lost. Further, this is an estimate based on land cover change observed over a ten-year period. If current data were available, the number would likely increase still further.

While mining and allied activities have created new employment opportunities that can be sought out by those who have lost agricultural work only men are able to benefit from these opportunities. The highly gendered division of labour and roles of men and women have stopped women from taking up employment in this sector. Most women in rural Goa are still primarily involved in household tasks, raising children and where possible agricultural work. No significant new employment opportunities have emerged for women to fill the vacuum caused by a decline in agriculture. A rough quantification of work lost at the rate of Rs. 50

[1] Data is not available for Cluster II.

per day for female agricultural labour indicates a loss of approximately Rs. 4 million per year in only two clusters.

Also this gender map throws light on work loss by agricultural labourers, which in this context are a marginalized group, since they feel the impacts of mining on agriculture, but are not entitled to the benefits/compensation paid by companies. Farmers reported that about 50% of transplanting, weeding, harvesting and threshing work is done with the help of agricultural labourers in the small farmers group and it is about 60 % among moderate/big farmers. Using the data for Clusters I and III mentioned above, this reveals that 11,146 male and 34,744 female work days are lost per year for agricultural labourers. As compensation is available only to owners and tenants of the land, the loss of work has a significantly stronger impact on labourers. While it is not within the scope of this project, it would be interesting to probe further the impact of this loss on labourers and to understand what kind of coping mechanisms they have developed.

Response of agents

Through long term interaction with farmers in the study area researchers were able to observe the responses of various agents to the decline in agriculture in the region. The table below shows us the different agents associated with agriculture.

Table 3A.3 Agents associated with agricultre

Agents managing and regulating overburden dumps	Agents supporting agriculture
Mining Companies	Farmers' Groups
The Indian Bureau of Mines (IBM)	Dept. of Water Resources
Goa State Pollution control Board (GSPCB)	Dept. of Agriculture
	Deputy Collector/Magistrate
	Panchayats
	Minerals Foundation

In the next section we have documented and analysed the role of three broad groups of agents, namely the companies, the government and farmers groups, that influence outcomes regarding agriculture in the mining regions.

Mining companies

Compensation

Companies have responded to the decline in agriculture by providing compensation to farmers for lost yields. Interaction with all three stakeholders reveals that there is no formal or regularised process for the payment of compensation for reduced yields. The process is ad-hoc and farmers' groups usually negotiate rates directly with companies. In Goa, agricultural land is often affected by run-off from several dumps belonging to different companies. In such cases each company pays a fraction of the compensation. Importantly, compensation payments are erratic and made every few years rather than seasonally or annually.

If there is a dispute between a company and a farmers group, the farmers usually approach the Deputy Collector to resolve the issue. In such cases the Deputy Collector requests an

agricultural officer to visit the land in question, estimate the extent of loss and the compensation that needs to be paid.

This process of compensation payments is problematic for the following reasons:

- The lack of clear guidelines or a formal procedure has led to mistrust within the community and between the companies and the farmers. Farmers often perceive that their group leaders are bought out or bribed by companies to settle for lower amounts of compensation. This leads to poor relations within the community. Additionally, both companies and farmers feel that they are being cheated by each other. Over the years this has eroded relations between the two groups.
- There is no monitoring of compensation payments by any state agent and companies are not required to report any information regarding compensation payments made. Thus, there is no state agent ensuring that the process is fair on behalf of the community.
- The amount of money paid to farmers is small, relative to the cost of dump management. Thus, paying compensation for reduced yields has not served as an incentive for better dump management practices.

Dump management

While it is necessary to compensate farmers for adverse impacts on the land, this is not a long-term or sustainable solution to the problem. The long-term solution to agricultural problems in the mining areas is improved dump management which would lead to reduced soil erosion.

Over the course of this project some companies have made an effort to better manage dumps, yet, much more work is required to ensure minimum run-off of silt. While some older dumps may be stable now, farmers still hold companies accountable for silt that has accumulated in the fields over the past several years when these dumps were not properly managed. As de-silting is a very costly option for companies they have resorted to offering farmers compensation plus inputs for agriculture (seeds, fertilisers) and extra inputs to rejuvenate the soil, with the understanding that compensation will be phased out over the next few years. These overtures have received mixed responses. While a few companies have had success several farmers are reluctant to accept such an offer as they are not convinced that the dumps have been adequately stabilised and there is a good chance of more silt entering the fields the following year. Because there is a lack of trust between these two groups, it has resulted in suspicion among farmers of any offer made by companies.

Government

There are two sets of state agents that have a role to play in this context; those that provide support to farmers and manage natural resources and those that regulate mining and industrial activities.

The most important agents involved with agriculture are the Department of Agriculture, which provides agricultural support to farmers, and the department of Water Resources which is charged within managing water bodies and irrigation projects. The responses of these two agents are summarised below:

Table 3A.4 Government agencies managing agriculture and water resources

	Dept. of Agriculture	Dept. of Water Resources
Monitoring	No attempt to map areas that are silted Data on yields not maintained No oversight or management of compensation payments	Monitoring of major water bodies and large reservoirs/ irrigation projects in the state No monitoring of second and third order surface water bodies used for irrigation
Management	Agricultural support programmes/schemes available but not suited for the mining areas No targeted programmes to respond to mining areas. No networking with other departments (IBM, Water Resources, State Pollution Control Board)	Desilting of major water bodies only No special programmes or response to problems in the mining region No networking with other departments (Agriculture, State Pollution Control Board, IBM)

Table 3A.4 above shows that despite the presence of mining for several years there is little or no monitoring of impacts and very little support for local communities.

Additionally, the Indian Bureau of Mines and the State Pollution Control Board have a role to play in terms of monitoring and enforcing regulations with respect to mining activities (including dump management) and with respect to prevention of pollution. The responses of these agents are summarised in the table below.

Table 3A.5 Government agencies with authority to enforce regulations

	Indian Bureau of Mines (IBM)	State Pollution Control Board
Monitoring	Monitoring of mine sites and activities across the state	No proactive monitoring of water quality in mining areas Generally respond only to complaints
Management	Poor enforcement of regulations regarding dump management	No networking with other departments (Water Resources, IBM)

Table 3A.5 reveals that regulatory agents of the state have been lax at enforcing various environmental rules and regulations. As a result, the root cause of the problem has not been addressed.

Farmers groups

Farmers groups in the study area have been created in the recent past in order to negotiate compensation with mining companies. These groups generally consist of farmers who own or manage small pieces of land that together to form one large plot. Other than collective bargaining for compensation the farmers' groups have not taken advantage of being in a group in terms of availing of government programmes collectively or planning for regeneration of their land.

Most farmers groups are large and may have as many as 50 to 70 members, but despite this farmers groups are not able to bargain effectively with companies and unable to mobilise help from the relevant government departments for a variety of reasons:

- The structure and functioning of the groups are weak, ie. non-democratic, lacking in transparency, ridden by factionalism, lack of leadership etc.

- Not all farmers are interested in rebuilding or restarting agriculture. Some farmers would prefer to continue receiving compensation in cash. Thus, it is difficult for groups to build consensus and easy for companies to influence group members.
- A lack of information and knowledge about different erosion control measures and other technical solutions has meant that in some cases when making demands from the companies they have failed to ask for proper dump management in their area.
- Lack of knowledge and information about various government departments and their jurisdictions. Unsure of whom to approach for various problems.

While these groups have tremendous potential to revive agriculture in the region, the reasons mentioned above have acted as barriers to effective participation in decision making with other stakeholders.

Conclusions

The findings presented in this section explain how mining has impacted land in the study area and the resultant decline in agriculture. Under the current conditions the cost of growing paddy has increased to the extent that it has become an unattractive option for farmers. As individual farmers have stopped farming the agricultural system has become unstable at a watershed level.

While both men and women have been affected in terms of work opportunities lost, women have lost more days of work than men per acre of land. Yet, mining and allied activities have not been able to provide alternative employment opportunities for women. Thus, the well-being of women has been disproportionately affected by mining.

Companies have responded to this problem by providing compensation to farmers for reduced yields, however, the methodology used to calculate rates is ad-hoc and the system lacks transparency and oversight.

State agents have an important role to play in monitoring and enforcing standards for overburden dump management and in monitoring and responding to changes in land and water resources. However, this report highlights the fact that these agents have shied away from their roles leaving farmers to tackle companies with little or no support.

3B Understanding environmental-health linkages: metal uptake in fruit crops grown on overburden dumps

Introduction

It is well documented that mining activities lead to various environmental and socio-economic problems. In the case of open cast mining, overburden dumps lead to a variety of environmental and land management problems that ought to be addressed. In areas that are densely populated, such as our study area in Goa, inadequate land for dumping mine rejects coupled with a high overburden to ore ratio leads to the formation of steep and high dumps that are eroded during the heavy monsoons in Goa. The runoff from these dumps then affects land resources in the area. A common way to deal with this problem is to vegetate dumps with a variety of grasses and quick-growing trees and plants which results in soil binding and stability and a reduction in the surface area exposed to rainfall. Guidelines for dump management increasingly call for planting of local varieties of trees and plants that can fulfil the needs of local communities. This includes fruit trees from which fruits can be eaten or sold; trees that provide fuel wood, fodder plants, etc. However, would locally grown fruit trees, for example, or any other edible crop grown on the dumps involve metal uptake in concentrations that can harm human health? It is necessary that before any recommendation for cultivating fruit trees on mining rejects is made, negative impacts on human health of such a recommendation be ruled out.

The uptake of metals by plants grown in soil contaminated with metals has been well documented. For example, accumulation of heavy metals (Zn, Cu, Cd and Pb) in vegetables and weeds grown on industrially polluted fields is higher than that shown to be in the non-polluted soil (Barman and Lal 1994). A study on the accumulation of heavy metals in vegetables, pulse and wheat grown in fly ash amended soil revealed higher metal contents than vegetables grown in the control soil. Parts of edible plants tested indicated that heavy metals such as Cu, Z, Pb concentrations are within the recommended limits whereas Cd, Cr and Ni showed slightly higher concentrations (Barman et. al. 1999). In another study, samples of perennial grass grown extensively in sewage sludge registered high levels of lead, cadmium, chromium, zinc, and nickel (Srikanth et al 1992). Similarly, heavy metal pollution in grass and soil around a cable factory in West Bengal showed a high percentage of extractable and total metal in surface soil than in deeper soils and from soils of relatively unpolluted area about 100 meters away from the factory. The amount of extractable metal in soils and roots showed a high correlation (Dutta and Mookerjee 1980).

Plants adopt several mechanisms to adapt to metaliferous soils. Physiologically, plants develop tolerance to metals through metal exclusion (blocking the movement of metals at the soil-root or root-shoot interface) or accumulation, which is allowing uptake of metals into aerial parts and rendering them non-toxic through chemical binding or intracellular sequestration (Baker 1981, Baker and Walker 1990, Ernst et al 1992, and Pollard et. al. 2002). Hyperaccumulator plants not only grow in soils with high levels of metals, but also accumulate pollutants in high concentrations in their tissues (Ebbs and Kochian, 1998). For instance, hydroponically grown T. caerulescens accumulated about 33,600 mg Zn kg-1, in its shoots (Ebbs et al., 1997). Some hyperaccumulators from Zaire, Ipomoea alpina Rendlek and Haumaniastrum katangense (S. Moore) Duvign. & Plancke could accumulate about 12,300

mg Cu kg-1 and 19,800 mg Zn kg-1 in their leaves, respectively (Baker and Walker, 1990). Leaves of Maytenus bureauvianus (Loes.) Loes. accumulated 33,800 mg Mn kg-1 in New Caledonia (Baker and Walker, 1990).

Metal tolerance is a property of a small yet diverse group of plants. A recently published inventory listed 418 species of vascular plants as being metal hyperaccumulators (Reeves and Baker 2000). This is a comparatively rare phenomenon when seen against the total number of vascular plant species, which exceeds 300,000 (Pollard et al 2002). However, metal hyperaccumulators come from a wide range of taxonomic groups and geographic areas, and as such have diverse morphological, physiological, and ecological characteristics.

Metal uptake by plants is a function of a number of factors of which soil properties and plant types are very important. The metal uptake from soil by plants through their roots both to their parts aboveground and to the underground storage organs depends on the amount of metal present in the soil in exchangeable or bioavailable form. Moreover, metal uptake is regulated by the ability of plants to transfer the metals across the soil–root interface.

Though metals such as Cu, Fe, Mn, and Zn are essential for growth and functioning of plants under normal conditions; when they are present in soil in excess of their required range, they pose environmental and health concerns similar to other heavy metals (Itanna and Coulman 2003). Contamination of the soil with heavy metals increases phytotoxicity and movement of metals into the food chain. Contamination affects the soil biota in its diversity, abundance and activity, and pollution of surface and ground water also becomes a concern. Abrahams (2002) has reviewed how human health is affected by the world's soils and suggested that such investigations should involve a multidisciplinary approach that both acquires knowledge and ensures its dissemination to people in an understandable way.

Toxicological effects of certain trace elements have been assessed by a number of toxicologists (Sandstr 1998). For example, Olin (1998) suggests that an overly high intake of even essential trace elements can lead to toxicity in plants (Olin 1998). Some studies in Goa have shown that morphological and reproductive characters of plants grown on mine reject dumps were affected and biochemical analysis has shown that the chlorophyll content, sugar and protein content in plants does decrease (Torney and Gaonkar 1989, Nayak 1994). Excess of Mn, which after Al is the most potential toxic element in acid soils, represents a growth-limiting situation for many crops in the soils that constitute vast areas of arable land in the world (Quartin et al 2001).

Accumulation of metals in plant systems also poses potential problems relating to movement of metals across the food chain. Toxicological effects on fish, both direct (physiological) and food chain mediated (bioenergetic) have been documented by Campbell et al. (2003). In the case of direct effects, the following linkages were demonstrated: chronic metal exposure metallothionein induction → perturbed intracellular metal partitioning → endocrine/physiological impairment → diminished growth efficiency → reduced survival, altered population age structure and population dynamics. In the case of food-web mediated effects, the following sequence was investigated: chronic metal exposure → reduced food

abundance of certain dietary components → increased energetic costs of feeding → reduced growth efficiency and ultimately stunting.

Toxicity in humans can be either due to direct consumption or through the food chain. The Iron Disorders Institute, South Carolina, U.S.A. works on exposure to iron. Some of the symptoms that they have reported for acquired iron overload are chronic fatigue, arthritic pain in joints, loss of libido or impotence, amenorrhea (premature cessation of menstrual cycle), changes in skin colour such as jaundice, bronze or grey-olive coloured skin, a tan without being in the sun, redness in the palms of the hands, abdominal pain, weight loss, shortness of breath, chest pain, heart arrhythmia, depression, elevated blood sugar, hypothyroidism and enlargement of spleen and elevated liver enzymes (ALT/AST).

Iron ingestion is one of the most common causes of pediatric poisonings in the United States (Morris 2000). Leung and Bartfay (2002) also report that acute iron poisoning remains a leading cause of morbidity and mortality in pre-school aged children in North America. Acute iron poisoning leads to organ damage, such as respiratory difficulties, cardiac arrhythmias, and possible death (Leung and Bartfay, 2002). Black and Zenel (2003) while reporting a case of paediatric iron poisoning cite various references to discuss the toxicological effects of iron. As discussed by them, iron is directly corrosive to gastric mucosa, and ingestion leads to diarrhoea, nausea, vomiting, and gastrointestinal bleeding. Metabolic acidosis attributable to iron toxicity results from several mechanisms. After absorption in the gut, iron is converted from the ferrous to the ferric state, thus releasing hydrogen ions into the serum. Hepatocyte absorption of iron leads to generation of free radicals, which can uncouple oxidative phosphorylation, causing anaerobic metabolism and the production of lactic acid. Free iron in the serum also has some effect on blood vessels, causing increased capillary permeability and loss of venous tone. Additional fluid losses in the gut, from hemorrhage and diarrhoea, and bradycardia from the cardiac toxicity of free iron accentuate the hypoperfusion, thereby exacerbating the lactic acidosis (Black and Zenel 2003).

Given that most of the mining activity in Goa is connected with iron and manganese ore and given that the soils in Goa have high iron and manganese content, it becomes necessary to study the implications of using mine reject dumps for food crop cultivation. However, there is inadequate research on metal uptake by local fruits grown on iron ore dumps.

With this in mind, the main aim of this component is to understand environment – health linkages in rehabilitation plans. The specific objectives of this component of the project are as follows:

- Examine in different mining clusters the distribution of vegetation grown on dumps
- Identify community preferences of crops grown on dumps through an assessment of end uses and costs and benefits of dominant vegetation
- Study metal uptake in food crops that are of interest to the local community

Methodology

Literature review

An extensive literature review was carried out on metal up take in plants and on toxicological effects of metals on biota. Available literature suggests that the metal uptake by fruits will depend on the type of the soil and the type of the plant. This creates location specificity for the issue under study i.e. metal uptake. Hence this component assessed metal uptake by local fruit trees grown under local conditions on the mining rejects in Goa.

Vegetation assessment

Field surveys were carried out in the study area in order to have first hand knowledge of what trees exist in the mining region, especially on dumps. Three field surveys were carried out across the study area to assess vegetation growing on dumps.

Focus group discussions

Focus group discussions were held, with a heterogeneous group of 12 –16 participants and included both men and women of different ages and educational and occupational backgrounds. Discussions were held to identify the following:

- Community perceptions about dump rehabilitation
- Community preferences regarding fruit crops and the reasons for their choices.

Pair-wise ranking was used to identify crops most preferred by the local communities. Pair wise ranking is an early tool in PRA, which compares pairs of elements such as preference for specific tree species.

The score for each crop was calculated as $S = \Sigma Pi$ where
$i = 1$ to n,
n = number of individuals
P = score given by each individual for that particular crop type

Matrix ranking exercises were used to get an insight into the reasoning and logic for selecting particular types of crops/ plants/trees. Matrix ranking exercise also served to validate results of focus group discussions and pair-wise ranking.

Costs and benefits identified by participants themselves were categorized and used for reasoning in the matrix ranking exercises.

Interviews with key informants

In addition to focus group discussions interviews were conducted with individuals working in government departments, researchers, local leaders in order to broaden the range of perceptions on preferences for fruit crops.

Assessment of metal uptake in fruit crops

A study on metal content in fruit crops was conducted to elucidate the relationship between the metal content of soil and its uptake by plants and accumulation in fruits and other parts.

Before conducting the final experiment a pilot experiment was conducted in order to standardize the methodology. For the pilot experiment, samples were initially selected from three mining sites (test) and one non-mining site (control). After the pilot experiment was successful and the methodology was standardized for estimation of metal uptake by fruits from trees grown on mining dumps, the final laboratory experiment was carried out. The concentrations of metals were estimated by total contents and DTPA (diethylene-triamine-penta-acetic acid) extractions.

The methodology used to estimate metal content is delineated below:

Sampling design

Eight sampling stations were identified. Biological samples collected from these places included fruits and leaves of mainly cashew and mango plants. Fruits and leaves of jackfruit, tamarind and other trees were collected, wherever possible. Soil samples were collected for each biological sample at root zone/sub-surface level.

Pre-processing of samples

Biological samples were thoroughly washed with tap water to remove any dust on the surface. This was followed by rinsing with distilled water. The samples, both soil and the biological sample were weighed and dried in a hot oven at 80° for 48 hrs. Dried samples were weighed again and ground to a fine powder. This powder (a known weight) was acid digested. The digestion was accomplished using a microwave oven at 105° for 15 min with 10 ml of concentrated analytical grade nitric acid.

Metal content analysis with atomic absorption spectrophotometer (AAS)

Subsequently the sample was diluted with double deionised water and the sample volume adjusted to a known volume. The extract was analysed using an atomic absorption spectrophotometer (AAS). The metal content was assessed for iron, manganese, nickel, zinc, and chromium, which are expected to be associated with Goan iron ore. Total elemental profile was determined using AAS.

DTPA extraction

The bio-available[2] fraction of metals in the soil was estimated using diethylene-triamine-penta-acetic acid (DTPA). DTPA extraction of the metals was carried out by shaking 5g of soil sample with 25 ml of a solution of 0.005 M DTPA and 0.01 M $CaCl_2$ for one hour. The suspension was centrifuged for 30 min at 5700 * g. and used to estimate metal content.

Statistical analysis

Relationships between the metal content in the soil system and that in the biological samples was assessed by simple linear regression analysis using Microsoft Excel programme (Sokal and Rohlf, 1981; Sonak and Bhosle, 1995). Correlation coefficients for the two parameters were also checked. As a minimum of six observations are necessary for carrying out simple linear regression analysis, the relationship between the two parameters could not be assessed for samples with fewer number of observations.

[2] Bioavailability is the degree to which a contaminant (in this case metals) in environmental media can be assimilated by an organism. Reduced bioavailability means a lower exposure of the chemical (metal) to the ecological receptor. Thus, the less the bioavailability of a metal, the less is its effect on an organism.

A major limitation in this study was that only a few fruit bearing trees could be found on dumps or on land affected by mining rejects. This is on account of many factors such as failure of mining companies to re-vegetate/ rehabilitate the dumps, preferred use of acacia or casuarinas to rehabilitate dumps, low tolerance/vigor among plants grown under difficult conditions such as soil with high metal content, and a lack of technical expertise among stakeholders to grow fruit trees.

Results

Vegetation assessment

The vegetation assessment carried out in the mining areas documented existence of fruit trees such as cashew, mango, jackfruit, banana, tamarind, jujube, sapota etc.

Three field trips were held for vegetation assessment in the study area. Most of the dump sites were found to be vegetated with acacia and casuarinas. Nevertheless, some fruit trees such as Anacarium occidantale (cashew), Mangifera indica (mango), Tamarindus indica (tamarind), jujupus jujube (jackfruit), jujube (boram), sapota, banana, were found growing on dumps at a few places.

Additionally, changes in land uses that have taken place in Goa during the ten-year period from 1988 to 1997 (TERI 1997) show that area under mixed crop has increased in all three clusters (see Table 3B.1 below). This indicates that there is a growing preference for mixed crop cultivation

Table 3B.1 Changes in land use (ha)

	1988	1997	Change
Cluster I			
Mixed crop	5404	6127	723
Forest	365	0	-365
Degraded land	489	329	-161
Cluster II			
Mixed crop	7105	7408	303
Forest	705	298	-407
Degraded land	1759	1361	-398
Cluster III			
Mixed crop	9179	10506	1327
Forest	10918	9836	-1082
Degraded land	1259	825	-434

Source. AEQM report, Table 3.2

Community crop preferences

Focus group research in Phase II of this project indicated that local communities would like to grow fruit trees on mine dumps for both self-consumption and for the market. In this component of the project, further focus group discussions and interviews revealed that most of the trees that the community identified to grow on dumps were of the fruit-bearing variety and had a good market value, besides being good for self-consumption.
Focus group meetings included discussions regarding cots and benefits of various trees/plants, end uses of vegetation, pair-wise and matrix ranking exercises. Results based

on these meetings show that there was very little difference in preferences across the three group discussions. (See Annexure B for results of matrix ranking exercises and summary of discussion on costs and benefits.) The trees that were most favoured are presented in Table 3B.2 below.

Table 3B.2 Community preferences across clusters based on matrix ranking

Rank	Cluster I	Cluster II	Cluster III
1	Teak	Cashew	Cashew
2	Cashew	Teak	Mango
3	Mango	Mango	Jackfruit
4	Kokum	Amla	Kokum
5	Jackfruit	Kokum	Amla
6	Amla	Medicinal plants	Tamarind
7	Sapota	Tamarind	Teak
8	Tamarind	Sapota	Sapota

Acacia and casuarinas were the least preferred, though these species currently form a major part of land rehabilitation by mining companies.

Table 3B.3 describes the main reasons for participants selection of various fruit trees.

Table 3B.3 Reasons for preferences

Preferred fruit trees	Reasons
Cashew	International market, uses for all parts of the plant, higher financial returns
Teak	High demand for furniture, high financial returns
Mango	Popular fruit, many local food preparations with high local demand
Kokum	Self-consumption and local market
Jackfruit	Self-consumption, value added products have local market
Aonla	Medicinal properties of value for self-consumption, demand for fruit from local Ayurvedic hospital
Tamarind	Self-consumption and local market
Sapota	Self-consumption and local market
Medicinal plants	Self-consumption, local demand

Looking at these results for the study area as a whole, there is a clear preference for Cashew and Mango trees followed by teak and kokum.

Assessment of metal uptake by fruits

In this component metal uptake in trees/plants and grass grown on dumps was assessed. A total of 53 samples from 12 different plant species were tested for the presence of metals.

1. Acacia
2. Aonla
3. Banana
4. Cashew
5. Casuarina
6. Grass
7. Jackfruit

8. Mango
9. Pineapple
10. Sapota
11. Tamarind
12. Tomato

For each plant/tree selected, the leaves, fruits, nuts and the soil surrounding the plant were taken as samples. Tests were conducted for five different metals including iron (Fe), manganese (Mn), Zinc (Zn), Nickel (Ni) and Chromium (Cr). Additionally, through DTPA extraction, soil samples were tested for metal content in bioavailable form.

The total metal content observed in each sample (soil and plant) and the total bioavailable metal content of soil samples are presented in two tables in Annexure B.

Initial analysis of the results showed metal tolerance in some biological samples. Metal tolerance is a quantitative concept and the concentration thresholds for describing a species as tolerant need to be defined. Table 3B.4 shows various concentration levels for uptake of metals by plants.

Table 3B.4 Plants as hyperaccumulators of metals

Element	Low	Normal	High	Hyperaccumulator (mg/kg)
Fe	10.00-60.00	600	2,500	
Mn	5.00-20.00	400	2,000	10,000-50,000
Zn	5.00-20.00	400	2,000	10,000-50,000
Pb	0.01-0.1	5	100	1,000 - 8,000
Ni	0.2-1.0	10	100	1,000-40,000
Cr	0.05-0.2	5	50	1,000-2,500
Iron levels in some species can be upto 35,000 mg/kg				

Source. Reeves et al., 1995

Based on the threshold levels presented in the table above, in the present experiment, 52 samples showed high accumulation of iron, 4 samples showed high accumulation of Mn, 22 samples showed high accumulation of Ni, and 5 samples showed high accumulation of Cr.

Statistical analysis

The key objective of statistical analysis was to identify the statistical significance of the relationship between metal content in the soil and in various parts of the plant. This was done through simple linear regression analysis. As stated earlier, one of the limitations of this component of the project was the absence of enough fruit trees on overburden dumps because of which several samples of each species could not be obtained. Tests of significance were conducted for all samples together and for cashew samples as there were sufficient cashew samples in the study.

The relationship between the metal content in the soil system and that in the biological samples assessed by simple linear regression analysis between the two parameters showed significant relationship between some metals and some biological samples but not all. It was observed that although there were totally 53 biological samples, on an average about 43

samples showed significant positive relationship between the different metals in the soil and those in the biological samples. In general, cashew showed significant positive relationship with the content of total Fe, total and bioavailable (DTPA extracted) Mn, total and bioavailable Ni, total and bioavailable Cr, and total and bioavailable Zn. Cashew showed no significant positive relationship with bioavailable Fe.

It was difficult to comment on other plants specifically as a major limitation of the study was absence of sufficient fruit bearing trees or plantation trees on mining rejects.

The results of statistical analysis are presented in different tables for specific relationship between the different metals in the soil system and the different biological samples.

Iron

Total 53 biological samples were assessed to check the possibility of iron uptake. Out of 53, only 43 samples showed significant positive relationship. In general, mango samples did not show significant relationship. Other samples, which did not show any relationship, were pineapple, jackfruit and Amla. However, no conclusions can be derived specifically for any particular plant/tree on account of small number of samples for each type of plant/tree. More detailed studies are needed to comment specifically on other plants. Another point that needs attention is that though cashew samples showed significant relationship for total Fe, no relationship was observed after bioavailable extraction of the metals in the soil system.

Table 3B.5 Results of statistical analysis between Fe content (total) in the soil system and in the biological samples

Total Fe and Cashew	R	N	P	p level	Significance level
All samples for Fe	0.136685	53	0.329091		Not significant
All samples for Fe	0.320265	43	0.036284	**p<0.05**	**Significant**
Cashew and Fe	0.219264	25	0.292306		Not significant
Cashew and Fe	0.408499	23	0.052962	**p<0.1**	**Significant**

R- Regression coefficient, correlation coefficient, N- Number of observations, p-probability

Table 3B.6 Results of statistical analysis between Fe content (bio-available) in the soil system and in the biological samples

DTPA Fe	R	N	P	Significance level
All samples for Fe				
Cashew and Fe	0.176648	25	0.398282	Not significant
Cashew fruits	0.360694	9	0.340275	Not significant
Cashew nuts	0.025807	9	0.947456	Not significant
Cashew leaves	0.046	7	0.921991	Not significant

R- Regression coefficient, correlation coefficient, N- Number of observations, p-probability

Manganese

Table 3B.7 shows that all biological samples (58) assessed for the uptake of manganese did not show any relationship between the metal content in the soil system and that in the samples (See Table 3B.7). However, a positive relationship was found between the total Mn content of the cashew samples and that of the soil system.

No significant relation was observed between the bioavailable metal content in the soil and all biological samples together. The relationship between bioavailable Mn content in soil and metal content in cashew fruits and the nuts was found to be significant.

Table 3B.7 Results of statistical analysis between Mn content (total and bio-available) in the soil system and in the biological samples

Total Mn	R	N	P	p level	Significance
Cashew and Mn	0.47249	28	0.01112	**p<0.05**	**Significant**
All samples for Mn	0.074378	58	0.578974		Not significant
DTPA Mn					
All samples for Mn	0.189647	59	0.150255		Not significant
Cashew and Mn	0.120843	25	0.565024		Not significant
Cashew fruits	0.7408	9	0.02241	**p<0.05**	**Significant**
Cashew nuts	0.74502	6	0.089234	**p<0.1**	**Significant**
Cashew leaves	0.387377	7	0.39058		Not significant

R- Regression coefficient, correlation coefficient, N- Number of observations, p-probability

Zinc

Biological samples (58) assessed for the uptake of Zn did not show a significant relationship between the metal content in the soil system and that in the samples. Similarly no significant relationship was found between total soil Zn content and Zn content in cashew samples. See Table 3B.8 below.

Table 3B.8 Results of statistical analysis between Zn content (total and bio-available) in the soil system and in the biological samples

Total Zn	R	N	P	Significance
All samples for Zn	0.233448	53	0.170601	Not significant
Cashew and Zn	0.093624	28	0.635594	Not significant
Cashew fruits	0.242708	8	0.562478	Not significant
Cashew nuts	0.049355	10	0.892298	Not significant
DTPA Zn	**R**	**N**	**P**	
All samples for Zn				
Cashew and Zn	0.196315	25	0.346952	Not significant
Cashew fruits	0.067715	9	0.862578	Not significant
Cashew nuts	0.447162	9	0.227513	Not significant
Cashew leaves	0.019424	7	0.96703	Not significant

R- Regression coefficient, correlation coefficient, N- Number of observations, p-probability

Nickel

No statistically significant relationship was seen between nickel content in biological samples (55) and the total nickel content in the soil system. However, a positive relationship was found between the total Ni content of the cashew samples and that of the soil system. Similarly no significant relationship was observed between Ni content in the biological samples and DTPA extracted Nickel in the soil, but a significant positive relationship was observed between the metal content in cashew samples and DTPA nickel in the soil.

Table 3B.9 Results of statistical analysis between Ni content (total and bio-available) in the soil system and in the biological samples

Total Ni	R	N	P	p level	Significance
All samples for Ni	0.024087	55	0.861427		Not significant
Cashew and Ni	0.437568	23	0.03679	**p<0.05**	**Significant**
DTPA Ni					
All samples for Ni	0.181821	45	0.231945		Not significant
Cashew and Ni	0.494873	23	0.011904	**p<0.05**	**Significant**

R- Regression coefficient, correlation coefficient, N- Number of observations, p-probability

Chromium

Table 3B.10 shows that biological samples (58) assessed for the uptake of Chromium showed significant positive relationship between the total Chromium content in the soil system and that in the samples. Similarly a significant positive relationship was found between the total Cr content of the cashew samples and that of the soil system. However, no statistically significant relationship was seen between bioavailable Chromium in the soil and Chromium in the biological samples. A significant positive relationship was observed between the bioavailable Chromium levels in the soil and Chromium content in cashew samples. Results of relationship between DTPA extracted metals for all samples need further study.

Table 3B.10 Results of statistical analysis between Cr content (total and bio-available) in the soil system and in the biological samples

Total chromium	R	N	P	p level	Significance
All samples for Cr	0.417163	55	0.001532	**p<0.05**	**Significant**
Cashew and Cr	0.633537	26	0.000512	**p<0.05**	**Significant**
DTPA Cr					
All samples for Cr	0.05434	46	0.719843		Not significant
Cashew and Cr	0.470018	21	0.031554	**p<0.05**	**Significant**

R- Regression coefficient, correlation coefficient, N- Number of observations, p-probability

Discussion and conclusion

Rehabilitation of overburden dumps is an important part of sustainable mining. Vegetating these dumps is a necessary step towards stabilising the structure and a productive use of the land. As increasing attention is focused on beneficial land uses of reclaimed land, there is a trend towards adopting and advocating vegetation which is useful to the local community, be it for firewood, for grazing or for food. However, in this context, potential metal uptake in

fruits needs to be verified as accumulation of metals can have implications to human health through food chain.

Several experiments have been conducted to assess metal uptake which suggest various factors influencing this. For example, in an experiment on mineral analysis that included nitrogen (N), potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), and Mn of dried plant material, Quartin et al., (2001) concluded that the cultivars Juanilho, Borba, TTE 9201 and BH 1146 (wheat) are more tolerant and that the cultivars Arabian, Beagle, TTE 9101, and TTE 9203 which are more sensitive. They report that the capacity to reduce the Mn uptake and therefore to avoid very high tissue concentrations in the leaf could be a strategy contributing to a higher tolerance in TTE 9201 and wheat BH1146.

Further, different vegetable species accumulate different metals, depending on environmental conditions, and metal types. In general, metals accumulate more in the root region than in other parts of the plants (Eriksson 1990). This metal uptake from the soil system depends on a number of factors, of which, soil type and plant variety are most important.

In our experiments it was found that cashew samples showed significant relationship between metals (iron, manganese, nickel and chromium) in the plant system and that in the biological samples. No such relationship was observed for Zinc. Of the total 55 samples selected, 43 samples showed significant relationship. This indicates that some plants might be accumulating higher quantities of metals, whereas others do not.

Similar results have been reported by others. For example, the concentrations of different forms of heavy metals (Fe, Mn, Zn, Cu, Cr, Ni, Cd and Pb) were determined in mine dump material rich in chalcopyrite by Alvarez et al (2003). The concentrations were compared with those of the natural vegetation colonising the dump. The heavy metal contents in the spontaneously occurring vegetation in the dump ranged between: 150 and 900 mg Fe kg-1, 84 and 2069 mg Mn kg-1, 20.5 and 106 mg Cu kg-1 and between 35 and 717 mg Zn kg-1, when considering all the plant samples analysed. Festuca sp. accumulated Fe, Salix atrocinerea accumulated Zn and Mn, and Frangula alnus and Quercus robur accumulated Mn.

A major limitation of the study was the presence of a few types of trees/plants on the dumps or mining rejects. Most of the dumps were either barren or re-vegetated with Acasia, and Casuarina. Only cashew samples were found at the most sampling stations. Hence the study had to compromise with several variables. In general, cashew trees showed significant positive relationship between metals in the soil system and in the plant system. On the other hand, mango samples did not show any relationship between the metals in the soil system and in the plant system. However, since more than 40 plants show significant relationship between metal content in the soil and that in the plant system, there is a need to identify plants/trees that accumulate metals. Detailed studies on plots on a trial basis are required to explore the possibility of metal uptake, if any, by the specific plants from the soil systems.

Chapter 4: Governance and health and well-being in the context of mining

Introduction

One of the major goals of in Phase III is to study and understand the role of governance in influencing outcomes related to health and well-being in mining regions. While the idea of governance is certainly not new, the concept and definition have evolved over time in keeping with the growing importance of governance in various sectors of development. In this component of the study we subscribe to the UNESCAP (2004) definition, which states that governance is "the process of decision-making and the process by which decisions are implemented (or not implemented)". The same authors suggest that an analysis of governance should focus on the formal and informal actors involved in decision-making and implementation and the formal and informal structures that have been set in place to arrive at and implement decisions (UNESCAP 2004). Thus, governance would apply to aspects of development where there are processes of decision-making and implementation; in other words, all aspects of development.

A study on governance requires a working definition of good governance as a benchmark against which governance in a particular context can be evaluated. Beginning in the 1980s the concept of good governance began to surface when large lending agencies such as the World Bank experienced serious implementation difficulties as a result of poor public management. These management failures were attributed to unaccountable, patrimonial and un-transparent governments (DSE, 2001). While the World Bank's initial understanding of good governance was limited to sound economic management, the concept of good governance has evolved considerably over time to include certain key principles (adapted from UNESCAP 2004), namely:

- Accountability
- Consensus orientation
- Effectiveness and efficiency
- Equity and inclusiveness
- Participation
- Responsiveness
- Rule of law
- Sustainability
- Transparency

These key principles are crucial for governance processes to be sustainable, pro-poor and gender sensitive.

Having identified a working definition of governance and good governance, we needed to establish what aspects of decision making this study would focus on within our mining ecosystem. In this context, the European Environment Authority's (EEA) Driver-Pressure-State-Impact-Response framework was used.

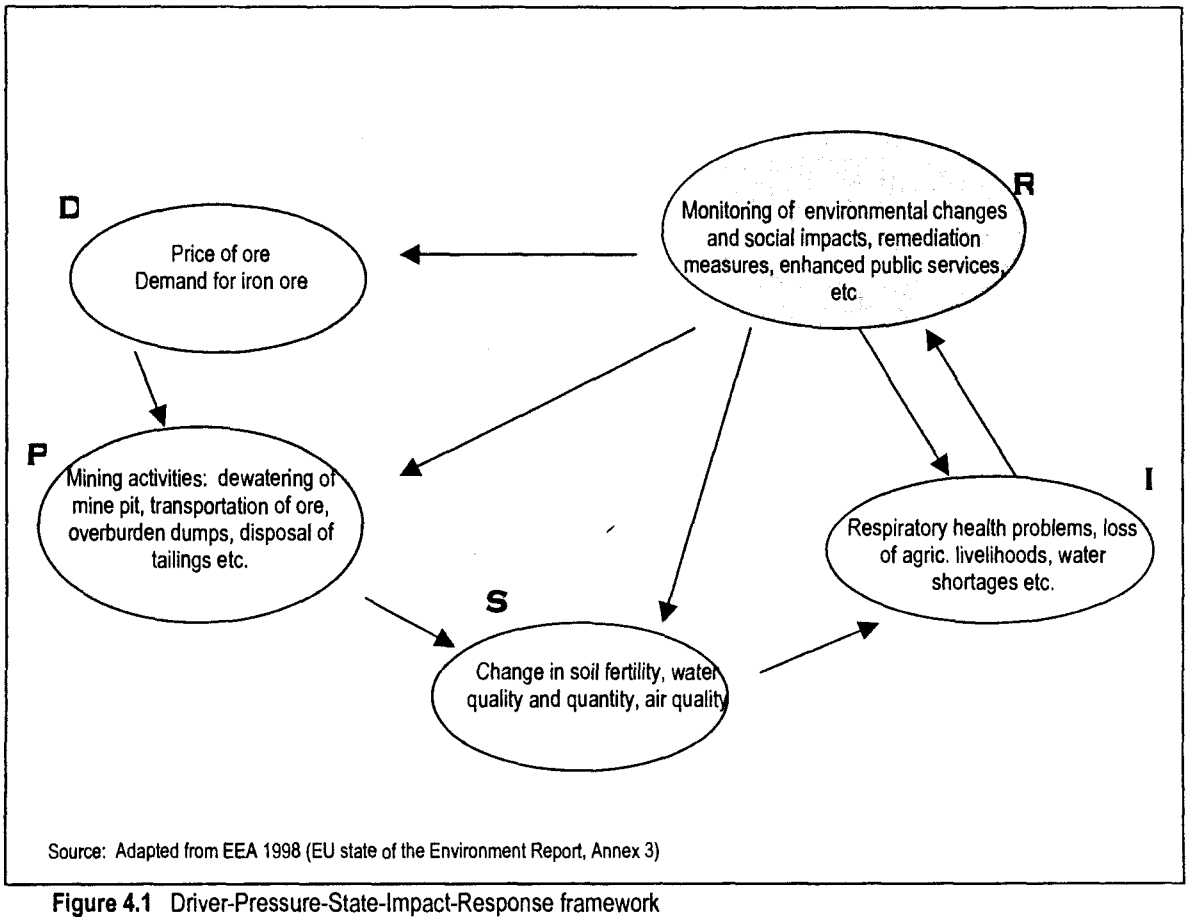


Figure 4.1 Driver-Pressure-State-Impact-Response framework

This framework identifies key Drivers of mining activities within the mining ecosystem, namely the demand for iron ore and the price of ore which. Mining activities, such as transport of ore or dewatering of mine pits in turn put Pressure on the natural environment leading to changes in the State of the environment. These changes have an Impact on various determinants of human health and well-being (livelihoods, health, social networks etc.). Through this framework we also identify the Responses from various agents (state, industry and community) which are a result of the process of decision-making and are integral to the study of governance. Specifically we are looking at responses in terms of the following:

- Responses to Pressures – better management practices/ technology
- Responses to State – monitoring of changes in the environment, enforcement of regulations and standards, remediation measures
- Responses to Impacts – monitoring of social impacts, enhanced public services, targeted support for local communities

In this study we focus on responses of various agents to changes in natural resources and their impacts on the local community and have attempted to answer a specific set of questions as follows:

- Who are the main actors involved in governance in a mining context?
- How is governance characterised in the study area?
- What factors influence governance in the study area?
- How can governance be improved in the study area?

As there are several natural resource management problems and human impacts occurring within our mining ecosystem, to further focus this study, three key issues that were of important in a mining context were chosen to be explored, namely

- Responses to poor air quality in the region
- Responses to changes in groundwater and shortages of water for household use
- Responses to changing community health status

Each issue met one or more of the criteria delineated below:

- The issue emerged as an objective condition that had a statistically significant relationship with subjective satisfaction in the Quality of Life survey conducted in Phase II. This means that the objective condition had a great influence on people's subjective satisfaction across the study area.
- The issue was emerged repeatedly as a problem during PRA exercises and discussions with local community members suggesting that it was of importance to them.
- Exploring the issue provided continuity in terms of cross-cutting research themes being explored in the project.

By taking a case-study approach, we delved deeper into each of these topics trying to unpack the processes of governance in each context. Additionally, research on land/agriculture and on-going interaction with farmers during capacity building exercises provided several insights regarding governance in the context of land management (documented in Chapter 2). These insights have been included in this synthesis where relevant.

Methodology

For this component of the study, we adopted both quantitative and qualitative methods to explore issues relating to governance. They are described in further detail below.

Survey

A household survey including 442 households in the study area was used to explore issues relating to air quality, water supply and the health care system. The survey had the following objectives:

- to assess the extent and severity of the water supply problem in the study area
- to understand the role of civil-society in the governance of issues relating to mining, with a focus on air quality and water supply
- to verify to what extent people use private health facilities (as this was reported during focus group discussions)
- to understand why people prefer private medical facilities (where they must pay) when the government provides a comprehensive health care system which is greatly subsidized and in many cases free.

Sample selection

The sample included the 17 villages which were selected in Phase II of this study to administer the Quality of Life (QoL) survey in the year 2000 so as to provide some continuity in the analysis. The justification for choosing these villages for the QoL survey was:

- Presence of a resource management problem, where it is worth adjusting management or policy to deal with the problem
- 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.

There have been changes in the study area since the QoL survey was undertaken therefore we updated the list of villages based on the health survey conducted in Phase III and interviews with local government officials.

Villages in Goa are made up of between 5-15 wards/hamlets and not all wards within a village have the same degree of air and/or water problems. Therefore we decided to take the ward as the smallest unit and attempted to stratify wards based on the degree of air and/or water supply problems they faced. Air quality problems are defined as a dust problem caused by mining activities and water supply problems are defined based on ground water conditions, as reflected in the level of well water in a ward.

To conduct the stratification we surveyed all village Panchayats in the selected villages regarding their air and water status with the assumption that a Panchayat would have information about each of its wards. Our sample frame included all those wards that experience either some degree of air or water problem. We assumed that air and/or water problems have no effect on the choice of health facilities and therefore no special consideration was made for the health section when deciding the sample frame. Using electoral rolls for the state of Goa we randomly chose households from these wards, ensuring that there was a proportional representation of each stratum as well as each of the three clusters in our sample. One individual in each household was interviewed and efforts were made to ensure that roughly half the respondents were men.

Table 4.1 lists the number of towns and villages included in the survey and Table 4.2 lists the number of households included in the survey.

Table 4.1 Towns and villages included in the survey

Cluster	Town	Village	Total
I	1	4	5
II	0	6	6
III	0	8	8
Road Corridor	1	0	1
Total	**2**	**18**	**20**

Table 4.2 Number of households in the survey relative to population

Cluster	Population (no. of households)	Sample (no. of households)	% of pop
I	1381	70	5.07
II	3195	161	5.04
III	3750	211	5.63
Total	**8326**	**442**	**5.31**

For the purpose of analysing people's responses to air pollution problems we have clubbed Cluster III and the corridor together. The main hypothesis in this context is that people are less likely to report air pollution problems if they are dependent on mining and allied jobs. In the road corridor a large number of people are dependent on the trucking business as are people in Cluster III. Thus, for the purpose of analysis in this case clubbing the two together made sense. Additionally, this does not affect the age of mining theory because the road corridor and Cluster III are adjacent to each other and the Road Corridor is only as old as Cluster III in terms of mining.

When analysing water problems related to tap supply we have removed respondents from Curchorem (the road corridor) and Bicholim Town which is part of Cluster I. This is because these areas are urban municipal areas that receive 24 hour water supply and this study is more concerned with rural water supply as the mining region is predominantly rural.

Interviews and guided discussions

In addition to data generated through the survey described above, for all three components of the governance section (air, water, health) interviews were conducted with government officers (Water Resources Department, Public Works Department, State Pollution Control Board, Indian Bureau of Mines, Directorate of Health Services, etc.), and civil society agents such as health care workers, truckers associations, bank mangers, tenants associations etc. The data gathered through these interviews has enriched the analysis by capturing precious nuances related to the local community.

Focus group discussion

Five focus group discussions were held with elected representative of the Panchayats. The number of participants ranged from 6 to 10 in each meeting. Of these meeting three were held exclusively with women elected representatives. The objective of these discussions was to understand the role played by Panchayats relating to various problems that emerge in a mining context. Additionally, one focus group discussion was held with state government department representatives at the local level. The aim of this meeting was to assess how these departments interface with the Panchayat.

Results

The three key themes that were explored in terms of governance are explained in brief below. (etailed analysis and results for each are presented in Annexure C.)

Air quality

In the study area high levels of air pollution (respirable suspended particulate matter) are caused by the handling and transport of iron ore. Over loaded trucks carry ore from within the mines to ports along the river where they transfer the ore to barges waiting there. Poor transport and handling practices (overloading, speeding, not covering trucks) coupled with bad roads results in spillage of ore along the way and continuous truck traffic causes re-suspension of this dust creating poor air quality conditions. As the road corridors pass through settlement areas the air pollution caused has an impact on local communities. While there is extensive legislation to address air quality issues, dust pollution continues to pose a problem in the study area. This study looks at the following:

- The political-economy of trucking and its impact on enforcement of regulations
- The community's role in solving the air quality problem

Water supply

Dewatering of mine pits is an integral part of mining operations where excavation is carried out below the watertable. This leads to a lowering of the watertable and impacts the availability of water for households in the vicinity since wells and springs begin going dry. This study looks at the following:

- The state's effort to manage groundwater
- Provision of alternative water supply for household use
- The community's role as a catalyst for better services

Health care

Mining activities exert pressures on the environment that have direct impacts on the health status of local communities. Good governance requires the state to respond to these problems through improved or enhanced health care. However, in order to do so, changes in health status must first be detected and acknowledged. Health data in Goa is poor and does not accurately reflect health status of communities in the study area. This study addresses the following:

- Availability of health data for the study area
- Problems at the local and policy level in monitoring health status

Land and compensation

Land and compensation issues have been addressed in Chapter 2. However, as we draw on several findings in this discussion we reiterate the main issues here.

In terms of impacts to land, siltation of agricultural fields and water bodies in the watershed has impacted agriculture by lowering agricultural yields as well as increasing the number of fields that are being left uncultivated. Mining companies compensate farmers for crop loss, but not for deteriorating land quality.

This component looks at the following:

- Compensation mechanism in place
- State's response to the decline in agriculture in terms of dump management and support to farmers
- The role of farmers' groups in reviving agriculture in the region

In the section to follow we identify the various actors or agents involved in responding to the problems delineated above, briefly characterise their responses and present a summary of key factors that influence decisions and implementation in response to environmental and social changes.

Who are the actors/ agents?

As the impacts of mining are largely felt at the local or village level, we wanted to explore the issues of concern at this level. Thus, studying the role of Panchayati Raj Institutions (PRIs), which form the lowest level of elected government, in dealing with the impacts related to mining was important. Each village has a Panchayat that is responsible for administration within the village, and therefore understanding how officials at this level make decisions became one of the goals of this component of the study.

In 1993 Panchayats received a shot in the arm through that 73rd and 74th amendments to the Constitution of India that sought to strengthen these bodies and give them the necessary powers to play a much bigger role in village development. This decentralisation of power has been hailed as a step forward for village development in India and has sparked intense interest in PRIs and their performance. Preliminary research in the study area showed, however, that while state governments have the mandate to devolve vast powers to PRIs, in Goa and in several states around the country, this has not actually happened. While Panchayats may have more powers than they did before 1993, the bare minimum has been devolved. Various state government departments still play a crucial role in management of natural resources and responding to various socio-economic changes in the region. The table below presents the roles of various agents in the context of air, water and health management in the study area.

Table 4.3 Role of Panchayats and other agents

	Jurisdiction of *panchayats* and other agents	
	Panchayats	***Other agents***
Air	• Monitoring and regulation of emissions from furnaces (for commercial purposes) in the village.	• Air quality management and emissions within the mine lease area – Indian Bureau of Mines (IBM) • Air quality management within the state, Emissions from industrial activities – State Pollution Control Board (SPCB) • Emissions from vehicular transport – Regional Transport Office (RTO)

Contd.

Table 4.3 *contd.*

	Panchayats	*Other agents*
Water	• Cleaning and maintenance of public wells. • Applications for piped water for the village (through a *Panchayat* resolution.) • Verification/ endorsement of individuals' application for free tap installation. • Request for water tankers during water shortages.	• Approval of application for tap water – Public Works Dept. (PWD) • Daily supply of tap water – Public Works Department (PWD) • Monitoring/ management of groundwater- Water Resources Dept. • Monitoring/management of water use within mine sites – Indian Bureau of Mines (IBM)
Health	• Implement preventive health programs such as maintenance of public wells, implementation of sanitation schemes • Can devise village specific schemes to supplement existing state government ones • Liaison with state government departments to address issues pertaining to health and sanitation	• Primarily responsible for the provision of health care, both preventive and curative at various levels in the state – Directorate of Health Services (DHS) • Health care for mine employees – Labour Welfare Commission
Agriculture and Compensation	• Development of (government) waste lands • Development and maintenance of grazing lands (government owned) (No jurisdiction over privately owned land)	• Support to farmers - Department of agriculture • Monitoring and management of water bodies, management of irrigation projects - Water resources Department • Settle disputes regarding compensation - Deputy Collector • Monitoring of dump management as a preventive measures- Indian Bureau of Mines (IBM) • Monitoring of water pollution – State Pollution Control Board (SPCB)

The table above briefly describes the jurisdiction of the Panchayat and other agents, vis-à-vis the various topics. While the Panchayat does have a role to play in terms of air, land, water and health related issues, it plays a limited role and there are a number of other agencies at higher levels of government that play a more important role in planning, decision-making and implement of these decisions. Thus, to study governance in the context of these issues we needed to understand the role of other agents in the process of governance as well and look at Panchayats as one of several agents involved in these issues

Widening the scope of this study allowed us to grapple with decision making among a wide variety of actors some of which play an informal but very significant role. Depending on the topic at hand, there were different agencies that played an important role in determining outcomes. Broadly, these agents include:

- State agents
  - Panchayat members
  - Representative of government departments (Agriculture, Water Resources, Pollution Control Board, Public Works Department, Health Services etc., Indian Bureau of Mines, Directorate of Health etc.)

- Civil society
  - Village leaders and powerful individuals within the village
  - Entrepreneurs (Truck owners, tanker owners)
  - Civil society groups – (farmers groups, truckers association)

- Industry
  - Mining companies

Characterising governance in the mining area

The table below characterises responses by various agents, to the changing state of air, water, land and health in the study area.

Table 4.4 Responses of various agents, to changing state of air, water, land and health in the study area

	Air quality	Water supply	Land and compensation	Health status
Government	• No monitoring of air quality in road corridor areas • Poor enforcement of air quality standards • Poor enforcement of truck loading standards	• Poor monitoring and management of groundwater resources • Provision of taps and tankers as an alternative source of water • Removal of free public taps	• Poor enforcement of laws pertaining to scientific dump management • No monitoring of compensation payments made by companies • No monitoring of changes in soil, water quality • No targeted support given to farmers	• Poor tracking of health status • No clear policy on health needs of populations in areas with environmental stress • No linkage made between environment and health
Mining Companies	• Ignoring overloading of trucks • Temporary solutions (like spraying of water on dusty roads, employing people to sweep roads etc)	• Supply of tanker water as an alternative	• Inadequate dump management measures • Payment of compensation for crop loss, but transparency in methodology used	• Ad hoc health camps • Provision of health care for mine employees
Local Community/ Civil Society	• Ad hoc protests/ complaints to responsible agencies • Willingness to trade health for work • Demand for mining/allied jobs	• Protest/complain about water supply • Demands for water tankers from companies and PWD/ *panchayats* • Use civil society groups to pressure state agents to respond • At times unable to take advantage of public services as a result of infighting	• Formation of tenants associations to receive compensation • Discontinuation of agriculture • Demand/ expect mining/allied jobs	• Demand curative health care (health camps from mining companies)

The summary table above highlights the responses of the three broadly defined agents in the study area. In terms of government agents we observe an unwillingness to respond to various changes in region and an inability to uphold the rule of law (eg. air pollution regulations). Where agents have responded as in the case of water (by providing tap water) effectiveness is low. Similarly, the removal of free public tap water supply suggests that decisions have been made with little attention to the principle of equity.

Companies in the study area show an unwillingness to abide by legal regulations resulting in poor environmental outcomes. While companies have responded to some of these negative outcomes that have emerged as a result of mining (eg. compensation for crop loss, spraying of roads to prevent dust, provision of tanker water) their responses are often unsustainable.

While the local community is responding to changes their responses are often ad hoc and short sighted and thus lead to unsustainable solutions. There is also a lack of consensus building and a lack of attention to equity within the community with the result that responses in terms of protests, complaints often lack the power of collective action movements.

Factors influencing responses

Through qualitative and quantative research we have tried to identify factors that influence or motivate decisions by various agents. Below are presented some of the key factors that emerge through the research.

Government

State agents responding to various problems respond at a policy level and at the local level in terms of implementation of various policies. Factors influencing decisions at these levels are different and are presented accordingly below.

- Strong industrial and political lobby groups

Mining companies are a powerful lobby group in Goa and have a strong influence on decisions of various state agents at a policy level. Through interviews with officers of various government departments it is clear that the pressure brought to bare on them has a strong influence on decisions related to monitoring of environmental impacts and enforcement of standards and regulations. State agents at the local level report that if they attempt to tackle issues such as air pollution or changes in land quality they are likely to get transferred out of the mining areas so that status quo is maintained.

This is one explanation for the lack of policy level decisions within various government departments to gather data or track environmental and social changes (eg. air quality, groundwater status). In all the issues probed, namely air quality, health care, ground water and agriculture, the lack of studies and/or data is probably the most serious lacuna in terms of governance in the mining regions of Goa (e.g. lack of groundwater monitoring studies, no air quality data from road corridors going through settlements, no systematic soil quality studies to detect changes in fertility, no monitoring of compensation etc). In some cases the absence of relevant data is then cited as an excuse by government departments to not enforce laws. In other cases, the magnitude of a particular problem is not recognised, precluding a targeted response (eg. changes in cropping patterns as a result of siltation). Thus, as

companies are a strong lobby group and wield tremendous power government departments and elected representatives are cautious of how they enforce various laws.

- Lack coordination between government departments in terms of data sharing and planning

Even where data does exist, we observe a lack of coordination in planning and data sharing which leads slow or ineffective responses to problems that could be dealt with much more efficiently. For example, the Directorate of Health does not work in tandem with the Pollution Control Board in terms of understanding, mitigating and managing environmental health problems. In the study area there is a general perception among health care workers that respiratory problems are high because of mining related transport. Yet, there has been no contact with the pollution control board regarding this problem. Additionally, the IBM, which collects quarterly air quality reports from mining companies, does not share this with the pollution control board in order to make enforcement of the law more effective.

Similarly, responding to the decline in agriculture requires the involvement of several government departments such as Water Resources, Agriculture, and Indian Council of Agricultural Research (ICAR) etc., that rarely come together to plan or respond to problems collectively.

- Graft

While there are several regulations relating to environmental management, enforcement of these laws is generally seen to be poor both at a higher level and at the local level. One of the reasons for this is graft or corruption within the system. While corruption is difficult to prove, community perceptions of corruption levels are high. It is commonly known, for example, that trucks carrying iron ore are overloaded because bribes are paid (and asked for) in order to prevent the enforcement of the loading standards.

- Health and well-being and income seen as substitutable

Several government servants at the state and local level seem to feel that the impacts of mining on the community are not really very serious. According to them, communities are benefiting from jobs in the region so they shouldn't complain about problems such as depletion of ground water. This kind of attitude also heavily influences decisions in terms of responding to environmental problems in mining areas. As health and well-being are seen as unimportant, state agents do not feel the urgency to respond. (See details of water supply study in Annexure Q for details)

- Village politics

Where the state has responded to problems through public services, such as tap water supply, responses were seen to be uneven across the study area and some areas were seen to be much better off than others. Researchers observed that decision making at the local level was influenced by village politics. This factor was seen to have a heavy influence on decisions at the Panchayat level because Panchayat members are themselves residents of the village and very much a part of the struggle for power at the local level. For example, in one of the villages visited, a landlord has refused to allow water pipes to be laid over his land. While the Panchayat could have taken action against the land lord, the local representative in this case

chose not to because he is a relative of the land lord. Thus, at times Panchayat members seem unable to carry out their roles impartially as they are embroiled in village politics.

- Party politics

The influence of party affiliations had an influence on decisions of most government departments and Panchayats. For example, if a village Panchayat is affiliated to the ruling party in the state, their applications for a piped network to the PWD tends to be attended to much faster. (See details of water supply study in Annexure C).

- Age of mining

As policy level decisions would apply to the whole mining region evenly, the age of mining does not emerge as a factor that influences decisions. Additionally, government department workers at the local level, such as Zonal Agricultural Officers, PWD officers etc. are often transferred to from one region to another. While there is a possibility that Panchayat members would be influenced by the age of mining, this did not emerge clearly through focus group discussions and interviews.

Mining companies

Factors that were seen to influence companies' responses to various problems in the mining region are explained below.

- Lack of commitment to social responsibility and sustainability

A commitment to corporate social responsibility and sustainability at minimum requires adherence to the law and ideally a level of performance that goes beyond legal obligations. Several mining companies in the study region seem to lack this commitment, as is evident form their responses to the various problems faced by the environment and the local community. For example, several companies failed to conduct Environmental Impact Assessments as required by the law. Compliance was only forthcoming after a court of law threatened to close down the mines that had not complied with the rules.

Where companies have taken mitigative steps, these steps are short term and unsustainable indicating that there is a lack commitment to solving the problem and to sustainability. An example is spraying of roads with water in order to keep dust levels down, while overloading of ore carrying trucks (causing dust pollution) goes unchecked.
As corporate social responsibilities have not been imbibed into company policy, these responsibilities continue to seem like burdens and are treated as such.

- Profit motive

It is obvious that for mining companies profit motive would be a key factor influencing their responses to problems in the region. Interestingly, profit motive was seen to be a crucial factor in decisions that led to both sustainable and unsustainable outcomes. For example, while making a choice between desilting of agricultural fields and paying annual compensation to farmers, companies tend to choose the latter because it is cheaper to do so. To further elucidate this, we cite the example of the Falwada Tenants Association which has a total of 19 Ha of land. Calculations to rehabilitate and regenerate the fields show that the

total cost would be around Rs. 25,115,617[1]. The cost of annual compensation paid to the association is Rs. 200,000. Even though these costs would be distributed between 7 companies (those located within the watershed and contributing to the siltation of the field), the share of desilting costs would be significantly higher than the share of annual compensation. In some cases companies have offered to pay for inputs such as seeds, fertilisers etc., and resisted any demands for desilting. Farmers say they have been receiving compensation for about 10 years now (irregularly though and the amount received varies each year). Assuming the amount was a constant and regularly paid, over ten years the 7 companies would still have paid out only Rs. 2,000,000 as opposed to Rs. 25,115,617 to clear up the fields.

Table 4.5 Cost estimates for desilting and compensation

	Total cost in Rs (USD$)	Cost/ha in Rs. (USD$)
Desilting	25,115,617.50 (545,991.68)	1,321,874.61 (28,736.40)
Annual compensation	200,000.00 (4,347.83)	10,526.32 (228.83)

On the other hand, comparisons between annual compensation and costs associated with better dump management practices to reduce run-off indicate that it is more cost effective in the long run to take preventive measures than continuously pay compensation for several years. Consequently we see mining companies taking additionally measures to better manage dumps in order to reduce run-off.

- Size of a company

The size of the company was also seen as a factor that played a role in they types of decision made. In our study area, mining companies operating are all small family owned enterprises and with the exception of one company having a market capitalisation of approximately Rs. 43.5814 billion or USD$ 947.421 million. Smaller companies not only have limited resources, they also have limited access to information and cutting edge technology. These limitations have a strong influence on decisions and responses to environmental and social outcomes of mining.

- Age of mining

In the case of mining companies, we did not find the age of mining having any significant influence on their responses. The lessons they learn seem to influence their decisions in all clusters they operate in equally.

Local community / civil society

The local community also has a role to play in responding to the various problems that they face in the mining ecosystem. Deteriorated agricultural lands, poor air quality, decreasing groundwater levels, increased risk of respiratory illnesses etc. are some of the impacts from

[1] The activities envisioned include the desilting the fields, an adjacent nallah (water channel), provision of soil amendments to enrich the soil and necessary soil and water conservation measures.

the changing environment that affect the larger community. The key factors influencing their responses to these changes are discussed below:

- Nature and intensity of impact

The nature of the impact felt by local communities had a significant influence on their decisions to take action or seek solutions to their problems. Some of the impacts of mining affect the basic needs of life and consequently these get more attention from the community than others. Depleting groundwater for example, has affected availability of water for household/daily use, which is basic to life and not possible to go without water. As a result, the community is more active about complaining or protesting about this problem. Siltation of agricultural fields on the other hand, is a gradual process, the impacts of which have been felt over time. Additionally, as some communities members have shifted away from agriculture to other types of work their dependence on farming has decreased. Thus, the community was seen to respond more quickly to pressures that strongly impacted daily life.

- Lack of unity and local politics

In the study area the local community is a heterogeneous mix of various groups of people differentiated by caste, level of education, income, land ownership patterns etc. As in any society, these groups vie for power leading to friction within the community. We often found these groups having conflicting perspectives and sometimes refusing to act together to address problems faced collectively. For example, in one of the study villages one group of farmers would not support another group in their efforts to have their irrigation pond desilted even though the desilting would benefit both groups. Through the survey conducted and through personal interactions people themselves identified this as a reason for inadequate responses, but they seem unable to find common ground to address some of their problems collectively.

- Involvement in alternate livelihoods/ dependence on mining/ allied jobs

Having mining/allied jobs affected the nature of people's responses specifically in the context of air pollution and land degradation. In the case of air pollution caused by transportation and handling of ore, the truck owners who are also residents of the mining villages, are often hostile towards any efforts taken to mitigate the problem or reduce impacts. This is because they perceive a threat to their livelihoods and worry that initiatives to address the problem will result in possible closure of mines. Several instances of intimidation and harassment of those perceived to be opposing mining activities were noted[2].

In the context of agriculture those having any other form of employment (mining or other wise) were more willing to trade the health of their agriculture fields for monetary compensation since they were not dependent on agriculture. As a result of this split in the community collective action to solve problems or push for responses by other agents has seen limited success.

[2] While conducting survey in an area in the Road corridor TERI researchers and surveyors were approached by an aggressive group of men asking us to record that there was no dust problem in their village and to leave. It was later learnt that the group leader is the sons of one of the main truck contractor involved in transport of iron ore in the area.

- Leadership

In the study area, we found that in general there were few people who could lead and motivate larger groups to participate in civil society initiatives. There are examples of people taking the initiative to lead action to resolve issues, but we found that such instances were often exceptions rather than the rule. The lack of leaders has resulted in ad-hoc responses or protests taIn some cases, leaders are 'bought over' by providing them, or members of their families jobs in the industry, or by paying them money, This form of co-option quashes popular movement that may arise.

- Information/ knowledge

The lack of information/knowledge was seen to be a crucial factor in the community's response to various problems in the study area. Information or knowledge is necessary for a community to successfully engage in civil initiatives. Lack of information and knowledge emerged in the following ways:

  - Timeliness of information

Public hearings that need to be held in the case of new mines or expansions of older ones, are inadequately publicised and people often hear about it only after it has been held. Thus, they were unable to participate in these meetings.

  - Poor understanding of the government machinery

Farmers have often not known how to move the system for redress when their fields have been inundated or silted as a result of poor dump management practices. They are unaware of the level at which they need to address the problem, which official to contact etc. In terms of air quality, more than 50% of respondents to the survey stated that they were not aware of the existence of the Goa Pollution Control Board that is responsible enforce air quality standards.

  - Language barrier

One of the biggest factors influencing community responses was the unavailability of legislation, circulars and other legal information in the local language.

The absence of information has ensured that the communities' responses are ad hoc and ineffective. This has resulted in frustration and a feeling among community members that they there are no solutions.

- Financial constraints

Financial constraints were seen to be an important factor influencing community member's willingness to be involved in civil initiatives. For example, at the time of strikes, not all truckers can afford to wait-out the strike or lose days of work due to financial constraints and responsibilities. Thus, despite being aware of the impacts of air pollution and the need for higher transportation rates some truckers are willing to make a trade-off between long-term health and well-being and shorter-term and immediate gains because of the existence of needs in the present. Such a predicament often rules out participation in actions where there may be financial costs and a long wait before benefits accrue to people.

- Age of mining

We attempted to understand whether the age of mining has any influence over the degree of participation or the level of civil society activity within the local community. The table below looks at levels of political activity in the study area (in relation to air quality and water supply problems). We see that in terms of proportions of respondents actively complaining about their problems, in all three clusters a high percentage of people have resorted to complaining. We notice that there is a detectable trend in the first two columns, where we see what proportion of people complained and the average complaints made per complaining person.

Cluster I has the highest proportion of respondents complaining, followed by Cluster II and then Cluster III. We also wanted to see the intensity of this activity amongst those who do complain and we see the same pattern here. Cluster I has a high average of 2.33 complaints per complaining person followed by Clusters II and III. In terms of participation in protest marches, the trend is similar except, there is a higher participation in cluster III than Cluster II. Lastly, we look at those respondents who said they regularly or always attended the Gram Sabha meetings and we find that the highest proportion of respondents attending these meetings were from Cluster I followed by Clusters II and III.

Table 4.6 Political activity across Clusters

Cluster	Percentage of those having problems, actively complaining (%)	Average Complaints/ Complaining Person	Participation in protest marches (%)	Always/ Regularly attending *Gram Sabha* meetings (%)
I	78.00	2.33	28.00	26.92
I	76.35	1.70	12.84	11.18
III	71.28	1.55	22.56	6.22
Total	**74.05**	**1.71**	**19.59**	**10.84**

In summary, Cluster I displays the highest level of political activity from among the three Clusters, with Cluster II next, followed by Cluster III, except in the case of participation in protest marches. We can say then, that the age of mining possibly influences the degree of response to impacts, from the local community. Over the years, it is likely that experience, increased incomes, better education etc, people become more politically active.

Conclusions

Through this component we have attempted to study and understand the role of governance in influencing outcomes related to health and well-being in the context of mining. We have characterised the responses of various actors to changes in the mining ecosystem and tried to understand what influences these responses and decisions made by the different actors.

Data presented in these case studies and in this synthesis suggest that all three agents need to respond more effectively to changes in the environment and to impacts on the community. While a robust legislative framework is necessary to address these problems, it is clearly not enough to tackle the impacts of mining. While companies need to pay more attention to

their legal/statutory obligations and corporate social responsibilities, the state needs to play a more proactive role in monitoring and responding to changes within mining ecosystems by ensuring compliance within industry. The catalyst for this kind of change needs to come from civil society through calls for more information, more transparency and demands for more accountability. The ESPI tool (addressed in the following chapter) developed over three phases of research provides a framework for better management of mining ecosystems by companies and government. Simultaneously, capacity building activities undertaken in this project (see Chapter 6) are the starting point of a long process of empowering communities in order to ensure that they can play a more active role in the management of this mining ecosystem.

Chapter 5: Refinement of tools

The main output of Phase II of this study was a set of three tools to track health, well-being and sustainability in mining regions. These tools included a set of Environmental and Social Performance Indicators (ESPIs), a Quality of Life (QoL) survey and Impact adjusted income accounts for the mining region in Goa.

One of the key objectives of Phase III is to refine these three tools. Further research taken up in Phase III has provided opportunities to revisit and further strengthen these tools in their capacity to track sustainability and health and well-being in mining regions. Refinement work on the three tools is described below.

5A Environmental and Social Performance Indicators (ESPIs)

In Phase II of this project a set of Environmental and Social Performance Indicators were developed for use by companies and government. The development of indicators involved the following steps:

- Development of an indicator hierarchy
- Development of sub-issues for each core issue identified in Phase I
- Development and pre-pilot testing of tools
- Evaluation of the indicator set by companies and government departments

Maintaining the indicator hierarchy developed in Phase II, and addressing the same core issues addressed in Phase II, in this phase we have attempted to refine the indicator tool. Refinement of the tool has included a review of the following aspects or issues:

- **Practicality of data collection and usefulness of data**

When reviewing the ESPI tool, the feasibility of data collection and the usefulness of information was reassessed keeping in mind not just Goan conditions but the wider Indian context. This was done with the end objective of having an indicator set that is practically possible to use and that provides useful data in the context of management decisions.

- **Framework for classification of indicators**

Indicators in Phase II were classified as response and result indicators. Result indicators were defined as those which highlighted the changes, and the causes and impacts of changes, ie. result indicators corresponded to Pressure and State indicators within the OECDs Pressure-State-Response (PSR) framework. Response indicators were those that highlighted responses to changes and impacts within the ecosystem, corresponding to Response in the PSR framework.

In Phase III the European Environment Agency's DPSIR (Driver-Pressure-State-Impact-Response) framework has been adopted to classify indicators in the tool. While both frameworks acknowledge a cause-effect relationship between social, economic and environmental systems the DPSIR framework has taken the classification a step further by

distinguishing between Drivers and Pressures and State and Impact and hence allowing for a more refined classification of indicators. The figure below explains how the cause – effect relationship works within a given ecosystem.

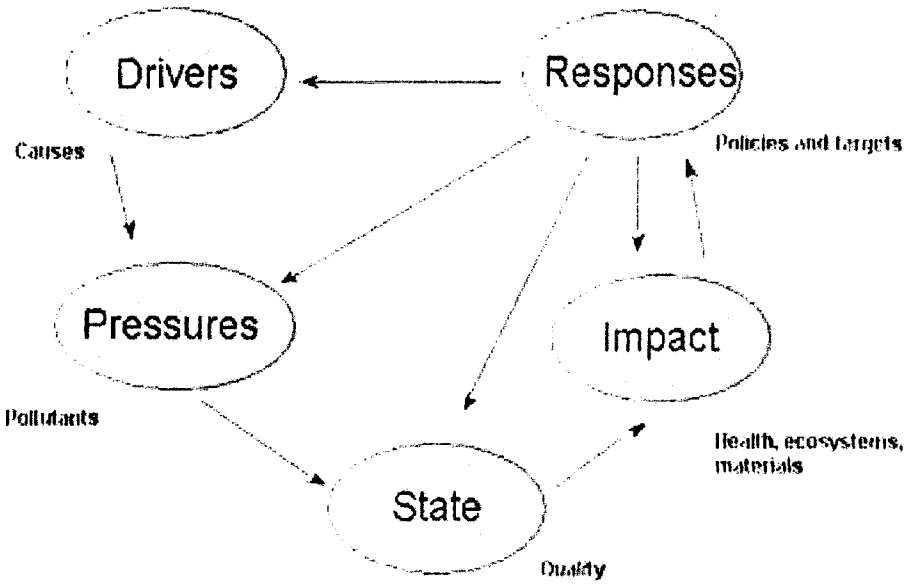


Figure 5A.1 The DPSIR assessment framework

Source. Based on EEA 1998: Guidelines for Data Collection and Processing - EU State of the Environment Report. Annex 3.

In addition to classification as explained above, indicators in this compendium are categorized as Primary or Proxy. Primary indicators are direct measures of the issue in question. Where a direct measure is not possible, proxy indicators provide indirect measures of the issue in question.

- **Level of data collection and analysis**

In Phase II village level indicators were meant to be used by Panchayat members or local government representatives at the village level. Phase II also acknowledges that at the local level there was a lack of information, limited capacity to understand the kind of data needed etc. Assuming these hurdles can be overcome through training and exposure, what remains problematic is that a lot of decision making is not done at this level. While Panchayats can and do effectively pressure other departments for better services, decision making powers are still largely vested with State government departments where there is a much greater level of technical expertise.

The studies on governance taken up under this project also originally intended to explore governance issues at the local level with a focus on Panchayats. This orientation was modified during the course of research because a variety of state and central government departments have a crucial role to play in managing and responding to environmental and social changes in a mining context. Thus, in this revised version, indicators for government are meant to be tracked and analysed by the relevant State Governments Departments. While this does not

preclude Panchayats from collating and analysing data as well it ensures that the onus of data collection and analysis falls on agents with appropriate technical knowledge and the power to make policy decisions.

- **Spatial scale for data collection**

Many state-level departments do not organise data at a village level. For example, Forest Departments in most states in India follow their own spatial scale of Circles and Blocks that do not match civil administrative boundaries. Similarly, departments dealing with water resources and health care services generally maintain data and make decisions at a Taluka level which is a higher administrative level than the village. While it might be possible to disaggregate data even further to a village level, the amount of time and resources spent possibly outweigh the benefits of having village level data for all indicators because decision making is not done at a village level. Thus, data for most of the indicators for government is required at a Taluka level. For some of the environmental indicators, data at a micro-watershed or watershed level has been suggested because the causal link between mining activities and environmental impacts is clearer at a watershed level.

- **Governance (good governance)**

The Core Issues identified by stakeholders in Phase I includes effective administration which is part of good governance; a key theme running through the research in Phase III of this project. Here the principles of good governance are not limited to government alone but extends to companies (and other agents as well.) Good governance in the context of mining would imply responding to pressures, states and impacts through monitoring of all three and through improved management decisions and policies. The table below provides a summary of how the principles of good governance identified through the research have been addressed in the tool.

Table 5A.1 Principles of good governance addressed in the ESPI tool

Principles of good governance	How principles are addressed in the ESPI tool
Accountability	Requests data gathering and analysis by agents with management and decision making powers
Effectiveness and efficiency	Highlights effectiveness by indicating the state of environmental resources and impacts on local communities
Equity and inclusiveness	Asks for data disaggregated by sex where relevant, highlights special attention to women and indigenous groups
Participation/ Consensus orientation	Includes indicators highlighting opportunities for community participation
Responsiveness	Highlights responses by companies and the State to environmental and social changes
Rule of law	Suggests legal obligations as minimum thresholds for various indicators
Transparency	Suggests data sharing between and within stakeholder groups

Keeping in mind equity as a key principle of good governance, when refining the indicators attention has been paid to marginalised groups, namely women and indigenous communities.

- Gender sensitivity

While there are almost no women workers involved in mining in the study area, in other parts of India women form a large part of the mining labour force. Additionally, women in the community are impacted by environmental and social changes related to mining. In order to ensure that the impacts on women are noticed and addressed, where relevant indicators ask for data disaggregated by sex. Additionally, some indicators ask about specific provisions for women/female workers.

- Attention to indigenous groups

While there are no indigenous groups in the community affected by mining in Goa, other mineral rich states in India have relatively large tribal and indigenous populations that are heavily dependent on natural resources for their livelihoods. As mining changes the state of the environment, these groups often lack the skills necessary to move towards alternative livelihoods. In order to ensure that the welfare of these groups is given special attention, where relevant, indicators regarding indigenous communities have been incorporated.

As good governance is necessary for the management of all domains within an ecosystem indicators that are reflective of the principles of good governance or effective administration are included in each section addressing a core issue. Rather than dedicate a separate section to effective administration or good governance we have incorporated this as a cross cutting issue in all domains.

- **Applicability to other metallic mining regions in India**

The indicator tool has been modified to ensure applicability to other metallic mining regions in India. Issues of concern that might emerge in other mining regions, such as the impact on indigenous communities, impacts on community health related to other metals have been addressed. Additionally, the indicators developed have been contextualised within the Indian legal frame work. Thus, mining laws and regulations have been suggested as thresholds for a variety of indicators.

- **Guidelines for use**

In order to operationalise the tool, indicators have been organised into a compendium with guidelines for use. Each indicator in the compendium has been explained through a set structure that seeks to highlight the following:

- Provide the title of the indicators
- Explain its placement with the DPSIR framework
- Identify what constitutes progress in the context of sustainable development
- Explain the importance of the indicator to sustainable development/ human health and well-being
- Identify units of measurement
- Identify the source of data
- Explain limitations of the data where relevant

The table below includes the number of indicators finalised under each core issue. For a detailed list of indicators see Annexure D. Additionally, see enclosed Indicator CD.

Table 5A.2 Indicator tool

	Companies	Government	Total
Background	3	10	13
Environmental quality	4		4
Water quality and quantity	6	4	10
Air quality	3	3	6
Land	5	3	8
Land compensation	3	4	7
Mine closure			
Socio-economic issues	5	5	10
Environmental issues	5	3	8
Health			
Health status	3	4	7
Health care	2	4	6
Participation			
Opportunities for participation	1	1	2
Information availability & access	1	2	3
Labour and employment	5	2	7
Social and community relations	6		6
Investment in the region			
Human capital	2	1	3
Physical capital	2	2	4

5B Quality of Life (QoL) tool

The QoL tool developed in Phase II of this project had three versions (with varying proportion of subjective and objective questions) all of which were piloted. Finally version III, with 75% objective and 25% subjective questions was used to gather data. Results from this version were presented in the final-year Phase II report.

In Phase III the data gathered from Phase II was used for further analysis where Chi-square tests were used to determine the association between objective conditions and subjective satisfaction. Additionally, multiple regression was used to identify those determinants which had a statistically significant relation with subjective satisfaction within each domain.

The main objectives of refinement in Phase III are as follows:

- update questions based on research in phase III to ensure that any emerging issues were covered
- improve clarity of questions where needed

Based on these objective, the QOL tool was modified in the following ways:

- **Reorganization**

At the conceptual level there were no changes made to the QoL tool. Most of the domains and sub-domains that were developed in Phase II have been retained in the final version of the tool. Some sub-domains were eliminated, though the questions were retained and reorganized under relevant sub-domains. This was done with the intention of maintaining logical links with the domains. Additionally, a similar reorganization was also carried out within the sub-domains where some questions were regrouped and reorganised into other sub-domains with the same purpose. For example, the sub-domain "Fuel used", under the domain "Economic" was removed and instead we created a new sub-domain "Basic amenities" where questions on fuel used, sanitation and water availability were regrouped.

- **Removal of questions**

Questions that were either repetitive or did not adequately capture the desired information were deleted. For example, under the sub-domain "Infrastructure" there were two questions that captured telephone usage, so one was dropped. In the same section, a question to capture expense on public transport did not tell us anything about the infrastructure, so it was dropped.

- **Additions**

Under some sub-domains, where information could be better captured additional questions were introduced. For example, in the "Biomedical" domain there was no question to capture whether there were any night/emergency facilities that people had access to, so such questions were included.

Figure 5B.1 below provides a summary of the domains and sub-domains within the final version of the tool.

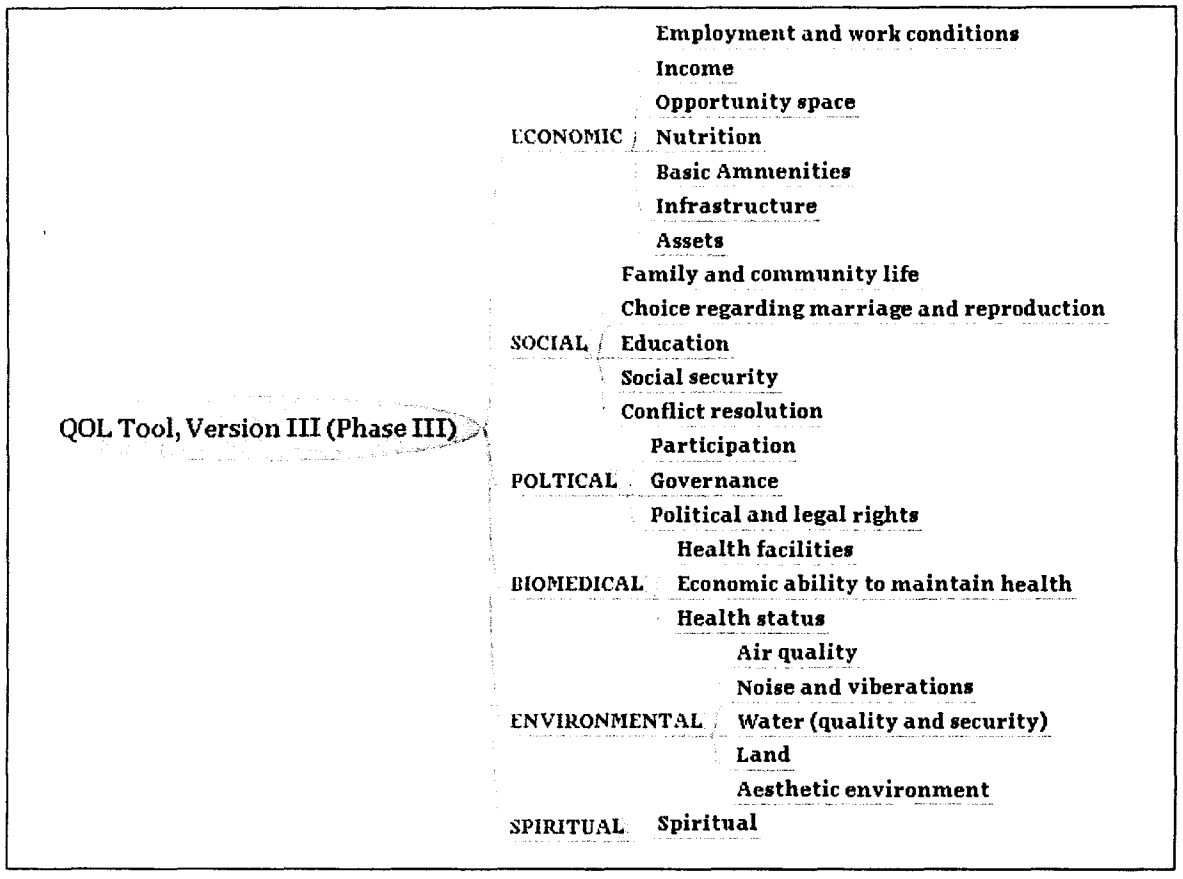


Figure 5B.1 Domain and sub-domains within the final QOL tool

5C Impact adjusted income accounts

A major component of the Phase II study included an accounting exercise that attempted to value the environmental and social costs of mining and accordingly adjust income obtained from mining to reflect true income.

The diagram below shows the various components that were included in the calculation of estimates for the purpose of such accounting.

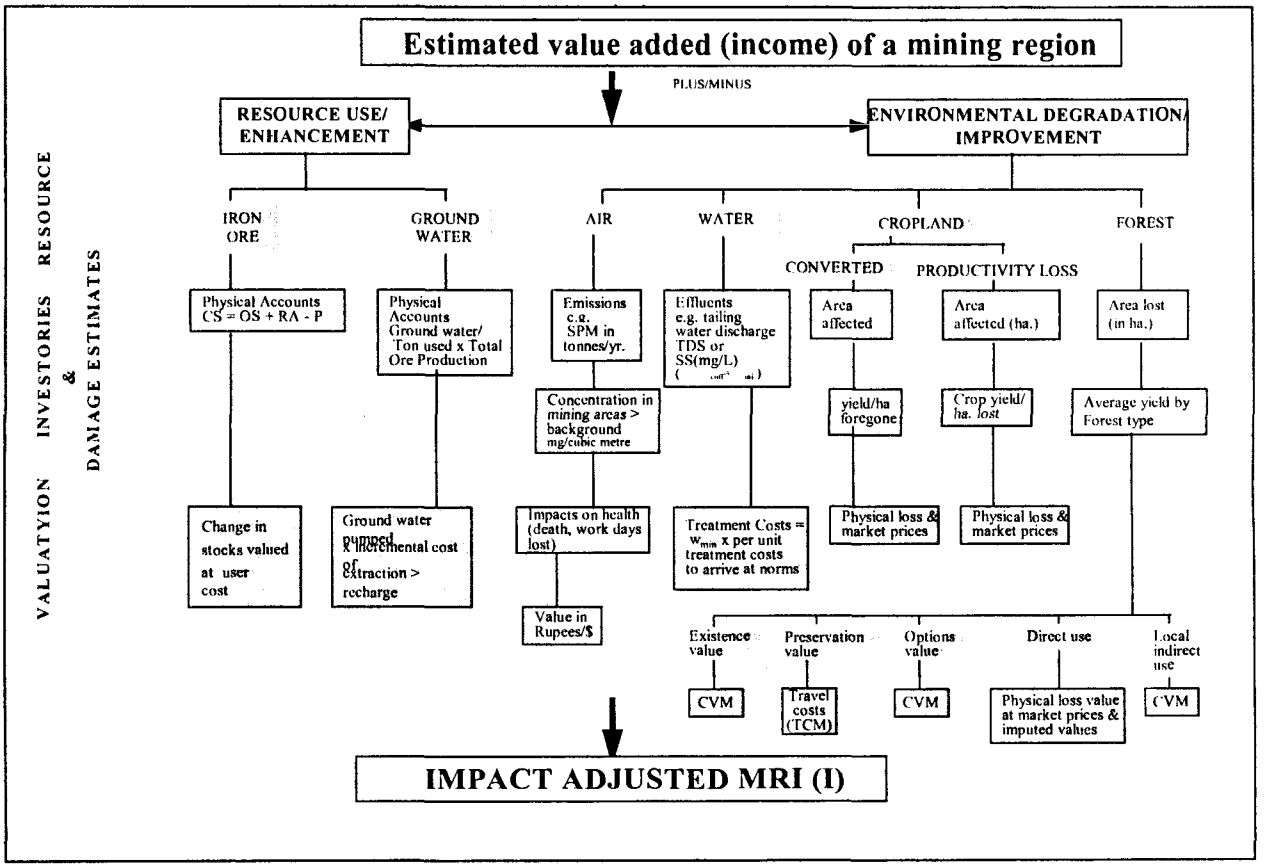


Figure 5C.1 Various components that were included in the calculation of estimates

As is evident from the above figure, this exercise involved the valuation of several environmental and social costs including health costs. One of the limitations in this project was the assumption in valuing health costs of air pollution that the dose response function for developed countries hold true for the study area. Additionally, there was a lack of sufficient information on cost of treatment and disability due to illness.

In Phase III, we have attempted to improve on this by developing an econometric model to value the health costs of air pollution.

Specifically, the objectives in Phase III were:

- To determine the community health status, focusing on the prevalence of respiratory problems among people in the mining area
- To assess the level of individual exposure to particulate matter of the people in the mining areas
- To determine the linkage between exposure to air pollution and occurrence of chronic respiratory problems
- To value the cost of ill-health or morbidity due to air pollution in the mining region using primary data and improving on the `cost of illness' approach through using a more transdisciplinary approach to valuation.

Figure 5C.2, below presents a summary of the steps that were taken in Phase III to address these limitations.

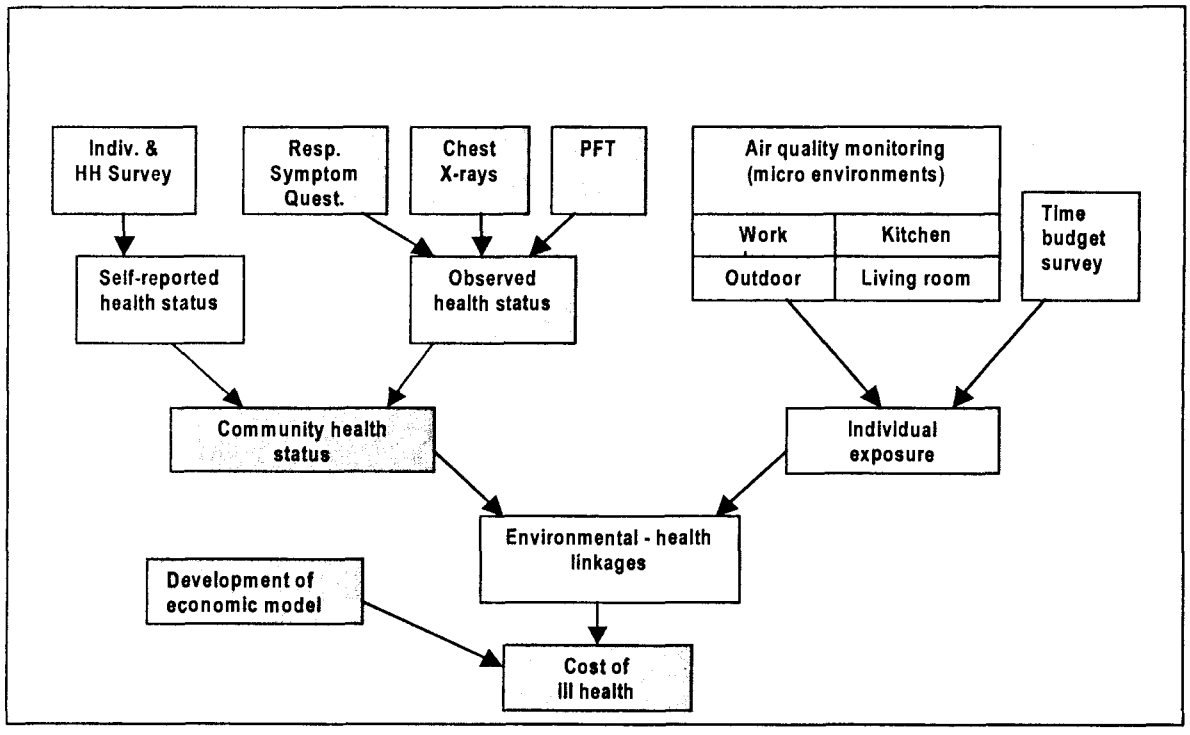


Figure 5C.2 Research components leading to the valuation of health costs

A detailed report of each of the research components that fed into the valuation are presented in Chapter 2. Below we summarise the results of the valuation exercise and discuss the changes in health costs obtained from this valuation as compared to estimates used in Phase II.

Table 5C.1 Comparing annual cost estimates from Phases II and III **(Rs. '000)**

Cluster	Phase II				Phase III	
	Lower estimates		Higher estimates			
	Total annual wage loss	*Annual medical expenses*	*Total annual wage loss*	*Annual medical expenses*	*Total annual wage loss*	*Annual medical expenses*
I	42.4	29.43	42.4	72.99	4,000.98	1,3860.72
II	2,043.9	1,420.13	2,043.9	3,521.83	5,877.06	1,9136.31
III	829.28	576.2	829.28	1428.94	2,608.116	8,033.04
Corridor	-	-	-	-	4,020.08	13,700.48
Total	**2,915.58**	**2,026.22**	**2,915.58**	**5,023.76**	**16,506.24**	**54,730.54**

In Phase II, lower and higher estimates of costs associated with annual wage loss and medical expenses due to respiratory illnesses were provided (Table 5C.1). In Phase III, we have a single estimate as provided above. Based on the new estimates of total annual costs associated with both, wages lost and medical expenses we see a marked increase from those reported in the earlier phase. The Phase II estimates were based on damages, impacts, wages and prices as recorded in 1997 (while using 1991 Census data). The Phase III estimates are based on data from 2005 (and 2001 Census data). There has been an increase in population between the two Census years of 1991 and 2001 and additionally, a new area, the road corridor has been included which was not considered before.

Table 5C.2 Comparing annual per capita costs for Phases II and III **(Rs.)**

Cluster	Phase II				Phase III	
	Lower estimates		Higher estimates			
	Per capita annual wage loss	*Per capita annual medical expense*	*Per capita annual wage loss*	*Per capita annual medical expense*	*Per capita annual wage loss*	*Per capita annual medical expense*
I	-	-	-	-	248	324
II	-	-	-	-	332	428
III	-	-	-	-	244	316
Corridor	-	-	-	-	496	640
Total	**121**	**205**	**121**	**335**	**330**	**427**

In Phase II, lower and higher estimates for annual per capita wage-loss and medical expenses due to respiratory illnesses were presented for the study area as a whole; cluster-wise estimates were not calculated. These estimates were improved upon through the model and we were able to get more refined information at the Cluster/Corridor level. We see that in all the three clusters as well as the road corridor, the annual per capita wage lost due to sickness is greater than the higher estimates form Phase II. Additionally, the Phase III average for the whole study area is also presented and is seen to be grater than Phase II estimates.

In terms of annual per capita medical expense due to respiratory sickness, the Road Corridor and Cluster II show figures greater than the higher estimate of Rs. 335 from Phase II. All Phase III figures under this head were greater than the lower estimates of Phase II.

Conclusion

In ecosystems stressed by minerals development there is a need to better manage and monitor changes in the determinants of health and well-being in order to develop responses that address the negative impacts such changes may bring. The tools developed and refined through the research address this need by helping to ascertain the sustainability of minerals development and to track changes in the state of natural resources, performance of different agents within the and the quality of life of those residing within the mining ecosystem.

Even though these tools have been developed in the context of the Goan mining ecosystem, the applicability of these tools is wide and they can be used in the context of minerals development elsewhere. These tools can be especially helpful in the larger Indian minerals context, given the vast expansion expected in minerals development in the country. The methodology adopted to develop these tools can be applied to tailor these tools in order to suit the minerals sector in other countries as well.

Chapter 6: Capacity building and dissemination

6A Capacity building

Over the course of research undertaken in the project researchers identified a variety of gaps in community capacity, some of which could be addressed through capacity building programmes. With these insights in mind, a variety of capacity building programmes were designed for the community. Additionally, some programmes have focused on building capacity with the research team and among NGOs and CBOs working in the study area.

In terms of health, the lack of hygiene and sanitation in some of the poorer areas were observed. By attending health camps (organised by other NGO's and agencies) as observers, researchers also noticed levels of under nourishment among children. Thus, programmes were designed to address these lacuna. Additionally, given the project's focus on respiratory health, and the high incidence of respiratory illness, programmes on early detection of respiratory problems were also chosen as a workshop topic.

Through research on subjects such as governance, gender, agriculture and water, researchers identified problems and shortcomings in skills and capacity within the community which make it difficult for people to respond to the challenges posed by a changing landscape. Some of these observations are as follows:

- Little or no participation of women in village development
- Very few local level institutions through which people can air their views or address problems related to mining. Those groups that exist are weak and ineffective due to a lack of leadership, vision, and clear goals.
- A general lack of information/awareness within the community and lack of skills and knowledge required to access various kinds of information among individuals and groups.
- Weak and ineffective local-level government bodies

Target groups

Addressing some of the problems we identified through the research requires social change that generally takes several years and continuous engagement with the community. As the study area for this project covered 53 villages and a relatively large population we needed to prioritise and plan with which groups we would work, in terms of capacity building. With a limited amount of time and resources, we chose to work more intensely with a relatively smaller group of people in order to be able to bring about change in the long run. Additionally, as TERI has been engaged in a variety of capacity building programmes for farmers and women's groups through other projects, we chose to continue working with some of the same groups in order build on those initiatives to see them through to fruition.

Health related workshops

A series of five half-day workshops on sanitation and hygiene conducted in each of the three clusters in the study area. The thrust of these programmes was to provide basic and easy to understand information on hygiene and sanitation and their link to health outcomes. Through the programme, participants were introduced to simple and cost effective ways to improve hygiene in their homes and localities. Additionally programmes on nutrition with a focus on children were conducted with local community women and nursery school workers. Programmes on early detection of respiratory illnesses was aimed at making participants aware of early symptoms and providing information on simple remedies that can be taken up. Table 6A.1 below, provides a summary of health related workshops conducted.

Table 6A.1 Health-related awareness workshops

Cluster	Village	Group	Topics covered	No. of participants	Date (2005)
I	Sirigao	Local community	Sanitation and hygiene and early detection of respiratory illness, prevention and home care	90	July 29th
II	Pale	*Anganwadi* workers	Nutrition and balanced diet for the family	25	May 19th
II	Advoi-Pissurlem	Local women	Early detection, care and prevention of anaemia and vitamin deficiency	30	June 1st
Road Corridor	Curchorem	Local women	Sanitation and hygiene and nutrition for under five children	20	June 8th
III	Sanvordem	Local community	Sanitation and hygiene and early detection of respiratory illnesses and prevention	35	July 27th

Strengthening local-level institutions

Over the course of the project researchers worked with farmer's and women's self-help groups in the study area with the objective of strengthening group functioning. Well-functioning groups (ie. groups that maintain transparency, elicit participation of all members, have clear goals and annual plans, maintain group discipline, have access to information, have strong leaders etc.) act as systems of support for women or farmers and have tremendous potential to address problems that arise at the local level. With this in mind, a variety of programmes/initiatives were taken up with local level institutions in the study area, as explained below.

Farmers' groups

Exposure visit to Van, Mavlinghe village watershed

22 October 2005

No. of participants: 5

A small group of farmers attended this exposure visit to a watershed project area in Goa. After brief presentations made by the watershed project team, an open discussion ensued between farmers from the mining areas and the watershed farmers focusing on how to resolve problems through a watershed approach.

Visit to overburden dumps

23 January 2006 – Chowgule and Bandodkar (Pale Mines)
24 January 2006 – Dempo and V. M Salgaocar (Dignem Mines)
17 February 2006 – Timblo and Quenim (Dignem mine and Cudnem Dump respectively)

The first and most logical step in the process of rebuilding agriculture is control of soil erosion from mine dumps; the root cause of silting of water bodies and land. Unless erosion is controlled, desilting and soil amendments end up being short term and temporary solutions. Understanding the importance of this step for sustainability, the Fal wada Tenants Association had drawn up a plan for rebuilding agriculture in their area. This included erosion control measures that need to be taken up by companies having dumps in the area as the first step, following which they have requested companies to take up desilting of their fields.

With TERI researchers acting as the go-between, these plans were presented to the companies who subsequently agreed to have two or three farmers from the Tenants Association visit each dump in the area (along with TERI staff) to ensure that work on the dumps is satisfactory. Visits were made to seven dumps in the area, following which a report was written with the help of TERI staff, on the adequacy of technical measures observed and on dump areas that need further work. This report has been handed over to the Goa Mineral Ore Exporters Association (GMOEA) to follow up with companies.

These visits have served to build capacity of farmers and company staff in many ways:

- Leadership building: This has been a good exercise in developing leadership within the farmers group. A few active members from the group have had fruitful interaction with mines managers and other company staff.
- Levelling: In general companies have always had the upper hand in their relationships with the community. The process of inviting farmers into the mine site to inspect the dumps and showing them around the dumps as guests, is a step towards equalising the relationship between companies and community.
- Technical knowledge: The dump inspections have led to increased technical knowledge about dump management, including erosion control measures, water harvesting, etc. among farmers. Additionally, farmers were good at identifying potential problem areas based on their own knowledge which they were able to share with company representatives.
- Communication: This exposure has been invaluable in terms of helping farmers to communicate constructively with companies (rather than fight) both orally during the visits and through the reports written up after each visit.

Water quality sampling with farmers

11 August 2006

Along with representatives of the Falwada Tenants Association, researchers collected water samples from streams and rivulets, which are known to originate from overburden dumps, or are fed by run-off from these dumps in order to check silt content in the drainage network. A technician from a government laboratory accompanied us to ensure that the methodology

adopted was sound. This exercise was completed recently during the monsoon season when run-off from dumps is expected to be high. This exercise was important for farmers because it demonstrated the manner in which water sampling is conducted, along with helping them make contacts with government laboratories so that they can employ similar techniques in the future if needed.

Strengthening farmer's groups: an exposure visit to MYRADA's watershed programme in Chitradurga, Karnataka
19 –23 December 2005
No. of participants: 14 (12 men, 2 women)

Through this exposure visit farmers from the study area were exposed to the work and achievement of successful farmers groups. The workshops and training included in this programme revolved around exploring the structure and functioning of successful farmers groups, vision building and planning and using a watershed approach for land management. As the Department of Agriculture in Goa is an extremely important point of contact for farmers we also invited agricultural officers from the Department for this workshop. The Department's work is often confined to providing technical advice and inputs at subsidised rates. Through this workshop they were able to see the need for and value of collective action and planning among farmers, especially in areas where land is impacted by mining or other industrial activities.

While women are as involved in agriculture as men (as discussed in Chapter 3), they are rarely members of farmers groups and almost never participate in meetings of this nature. Thus, one of the highlights of this programme was the participation of two women in a thoroughly male dominated sphere. Their willingness to participate was especially surprising because this was a six-day trip and they knew they were the only women attending (other than TERI staff). We attribute their willingness to participate to a level of trust and comfort that has been built up with TERI researchers through work with their farmers group since 2004.

Women's groups

Training for community organisers
In order to ensure that the skills necessary for developing and strengthening local level institutions stay within the community, training for community organisers is imperative. With this in mind, a training programme for community organisers/trainers was conducted through ten modules over a 10-month period (December 2005 to September 2006). The modules covered a variety of topics that are necessary for setting up and strengthening self-help groups or other local level institutions. The trainees, all of who are themselves members of local level institutions, were encouraged to try out these modules with their groups or with new local groups and provide feedback when they attend the following Module. Totally, 8 trainers have undergone all 10 modules of this programme[1]. Faculty for some of the modules of the programme were engaged from MYRADA, a Bangalore based NGO that has been

[1] While this programme stated out with 15 participants, over the first few months five participants dropped out (as expected). Two others attended irregularly and have missed several key modules.

working exclusively on poverty alleviation through local level institution building for over twenty years. A local artist who is also a social worker was engaged to help with these workshops by designing visual aids for training modules, which can later be used by trainers in the future. The work done during these modules has been documented and used to create a manual for trainers. Table 6A.2 lists the training modules conducted between December 2005 and September 2006.

Table 6A.2 List of training modules conducted between December 2005 and April 2006

Module	Title	Duration
Module 1	Social analysis of society	12th - 14th December, 2005
Module 2	The Development Cycle, Concepts of Self Help Affinity Groups	14th –16th January, 2006
Module 3	Structure and functions of successful groups I	11th – 13th February 2006
Module 4	Structure and functions of successful groups II	18th – 20th March 2006
Module 5	Rules and regulations	1st – 3rd April 2005
Module 6	The need for participation within groups	17th - 19th July 2006
Module 7	Why do we need SHGs?	25th and 28th July 2006
Module 8	Forming an SHG in the field	7th, 8th and 18th August
Module 9	How to conduct an SHG meeting	14th and 16th September 2006
Module 10	Responsibilities of members and representatives	29th September 2006

Training for members of local government

Focus group meetings conducted with members of the Panchayats, highlighted the need for training for these elected representatives in terms of gender awareness and in terms of general functioning. The following programmes were taken up through the project:

Deconstructing gender roles: an exploratory workshop for women Panchas (elected representatives)

Two workshops, held in North and South Goa focused on the following issues:

- Understanding the difference between sex and gender
- Gender biases in society and in my life
- How do Goan women fare relative to the rest of India
- Exploring the role of women elected representative
- Why women's attendance at Gram Sabhas (village assembly) is important

Table 6A.3 Details of the exploratory workshops held for women *panchas*

Study area	Dates	Number of participants
Cluster I and II	7th and 8th July 2005	16
Cluster III	1st and 2nd September 2005	12

Residential training programme for Local Elected Representatives
18-19 February 2006
Ponda, Goa
No. of participants: Day 1= 15 (12 women, 3 men), Day 2= Cancelled

This workshop was designed to cover a variety of topics based on feed back and information gathered from elected representatives during focus group discussions and based on researchers' insights, namely: preparing village development plans, fund raising, participation, public speaking, leadership qualities, inter-personal skills, availability of information etc.
The first day of the workshop went off well and the feedback received from participants was positive. However, despite signing up for the whole workshop most participants refused to stay overnight and decided to go home[2]. Additionally, many of them were not planning to return the following day.

Women's Gram Sabha
The Panchayat (lowest level of elected government) holds a Gram Sabha or village assembly every three months in each village where women's participation is very low. In order to increase awareness about the village assembly and encourage women to participate, a series of women's assembly meetings were held a few days before the village assembly. A variety of issues such as women's legal rights, gender roles, women's health etc. were addressed at each meeting through films, and speakers. These meetings were interactive and always included discussion or experience sharing. The following meetings have been held:

Table 6A.4 List of women's *Gram Sabha's* meetings

Date of meeting	Village	Number of participants
20 October 2005	Sirigao	39
20 April 2006	Pissurlem	48
24 April 2006	Mayem	52
26 April 2006	Sirigao	30
26 July 2006	Sirigao	52
28 July 2006	Pissurlem	32
13 October 2006	Molem	25

Although these programmes have been presented according to different themes, in many ways these initiatives have been linked. For example, we have mobilised self-help group women to take up health issues or participate in Gram Sabha meetings. Similarly, we have used the women's Gram Sabha (discussed above) as a forum to explore issues of health and hygiene.

[2] When planning this workshop, participants (especially women) were specifically asked whether an over night programme would be suitable to them. The workshop was planned as an overnight event as a result of positive feed back from several Panchas.

Programmes for the TERI team and NGOs

In addition to capacity building programmes for the local community and local elected representatives, a few workshops were also taken up to build capacity within the team and within research/community development teams working in other NGOs. Specific workshops attended by team members include the following:

Social analysis systems

This programme was attended by four TERI team members. The other five participants belonged to watershed societies and the Minerals Foundation of Goa.
Dona Paula, Goa
15 – 18 April 2005
No. of participants: 9

Workshop on mobilizing women Panchas

Pune
2 –4 October 2005
Attended by Ms. Anuradha Joshi (TERI Research Assistant)

Time series analysis using econometric software

Goa University, Goa
29 April 2006 – 3 May 2006
Attended by Ms. Yogita Mehra (TERI, Research Associate)

6B Project outputs and dissemination

Project outputs

Tools to track sustainability, health and well-being

The three tools developed over Phases I and II of this project have been refined in Phase III. The three tools include

- Environmental and social performance indicators for metallic mining regions in India
- Economic model to value the cost of illhealth
- Quality of life survey tool

These three tools have been revisited and refined based on the research taken up in Phase III of this project. (For details see Chapter 5)

Self-help Affinity Groups: a Trainer's Manual

Experiences and knowledge gained through the Training for Trainers capacity building programme were documented and used to develop a manual for trainers. The manual is in the local language and includes visual aids that can be used by the trainer in their future work. This manual has been developed with participants of the programme by using their experiences and stories to elucidate concepts and ideas. Although this manual discusses the creating and strengthening of self-help groups, many of the concepts can be extended to other community based organizations as well. This output helps ensure that even after the project is over, communities have some reference to continue with their work. Additionally this manual is valuable since there is little or no literature available in the local language.

Papers/Presentations

Papers and presentation from the project have been useful in terms of disseminating our research as well as getting valuable feedback from different forums to refine our work.

Dissemination

Workshops

Multi-stakeholder workshop
23 June 2003
Dona Paula, Goa

The objective of this meeting was to share with stakeholders the following:

- The conceptual framework for the development of tools to track health and well-being in the mining regions
- The development and testing of environmental and social performance indicators
- The development of the Quality of Life (QOL) tool.
- The concept and results of impact accounts for the mineral sector

Reviving agriculture in the mining areas of Goa: towards an integrated approach
20 January 2006
Ponda, Goa

The objective of this workshop was to disseminate findings on some of the most prevalent hurdles or problems in agriculture in the mining areas and to emphasise the need for a new and more dynamic approach to revive agriculture in the area. In addition to company representatives, the workshop participants included representatives from a range of government departments that play a role in agriculture including the Department of Agriculture, Water Resources, Indian Bureau of Mines, State Pollution Control Board and sub-divisional magistrates who are involved in settling compensation disputes.

Health well-being and sustainability in the mining regions of Goa
17 October 2006
Hotel Nova Goa, Panaji, Goa
No. of participants: 43

The objective of this workshop was to disseminate key findings regarding health that have emerged in the course of this study. Representatives from the companies, government, community, doctors from the study area and members of the Institutional Ethics Committee attended this workshop. The dissemination of research findings generated lively discussion on topics including health status of the residents in the mining area, health care services, air pollution, transportation of ore, land remediation and the ESPI tool.

Presentations

We have had many external presentations of the project for feedback to various people as listed below:

- Noronha L. 2003. **Ecosystem approaches to human health and well-being: Illustrations of use in a mining context.** Key note presentation at the forum on International Forum on Ecosystem Approaches to Human Health, 18 to 23 May 2003, Montreal, Canada.
- Dayal V, Datt D, and Murugesan A. 2004. **Assessing the impact to health in mining regions: ecosystem and mainstream economic approaches.** International Society for Ecological Economics (ISEE) Conference, 11 to 12 July 2004, Montreal, Canada.
- Cooper S. 2004. **Sustainable livelihoods in the mining industry.** Presentation made at the Sustainable Livelihoods Workshop, Organized by World Business Council for Sustainable Development (WBCSD) on 20 August 2004, Mumbai, India.
- D'Souza M. 2004. **Women's health in the mining regions of Goa.** Presentation made at the International Women's Health Meeting (IWHM), State Level Workshop, on 26 November 2004, Panjim - Goa, India.
- Cooper S, Mehra Y, and Kazi S. 2004. **Beyond curative care: the role of governance as a cross cutting issue determining community health and well-being** . Paper presented by Shirin Cooper at parallel sessions on 'Transdisciplinary approaches to research for health policy' and as a poster presentation linked to a parallel session on Equity. Global Forum for Health Research, Mexico City, 16 to 18 November 2004.

- Cooper S. 2005. **Linking governance and human security: stories from the mining villages of Goa.** Presentation made at the National Seminar on Governance and Security Part II, New Delhi, Organized by Delhi Policy Group on 8 June 2005, New Delhi, India.
- Mehra Y. 2006. **Working with stakeholder groups to encourage responsible mining: the TERI experience.** Presentation made at the Forum DSDS 2006 - Responsible Mining Side Event, TERI, Habitat Center, New Delhi, Organized by TERI, 2 to 4 February 2006, New Delhi, India.
- Uma R, Murugesan A, Dayal V, Das S, D'Souza M, Seghal M, Datt D and Mehra Y. 2006. **Valuing environmental-health linkages from air pollution in mining regions.** Poster presentation made at the Delhi Sustainable Development Summit 2006, Habitat Center, New Delhi, Organized by TERI, 2 to 4 February 2006, New Delhi, India.
- Cooper S. 2006. **An introduction to mining in Goa.** Lecture given at the Goa Institute of Management Studies for Goa Civil Services Officers Programme, 5 April 2006, Organized by Goa Institute of Management Studies, Ribandar, Goa, India.

In addition to the presentations detailed above, several presentations have been made for visitors/ reviewers/ stakeholders as follows:

- The Ethics Committee
  Project presentations on a continuous basis for their feedback and comments
- Dr. Jean Label, Director, Environment and Natural Resource Management (IDRC), June 2003
  Project presentations
- Dr. Rachel Nugent, National Institute of Health, November, 2003
  Project presentation followed by field visit
- Goa Mineral Ore Exporters Association (GMOEA), February 2004
  Project presentation
- IDRC Vice President, Resources, Denys Vermette and Regional Controller, Rana Auditto, December 2004
  Project presentations followed by field visit
- IDRC Board of Governors, March 2005
  Project presentations and field visit
- Dr. Anna Boischio Senior Program Specialist, November 2005
  Project presentation followed by field visit
- Project Peer-Review TERI, New Delhi, February 2006
  Presentations on each research component for feed back and comments
- Dr. Eduardo Mota Professor, Instituto de Saúde Coletiva, Universidade Federal da Bahia, May 2006
  Project presentation followed by field visits.

Papers

- Cooper S, Mehra Y, and Kazi S. 2004. **Beyond curative care: The role of governance as a cross cutting issue determining community health and well-being.** Paper presented by Shirin Cooper at parallel sessions on 'Transdisciplinary approaches to research for health policy' and as a poster presentation linked to a parallel session on Equity. Global Forum for Health Research, Mexico City, 16 to 18 November 2004.
- Cooper S. 2005. **Linking governance and human security: stories from the mining villages of Goa.** Presentation made at the National Seminar on Governance and Security Part II, New Delhi, 8 June 2005, organized by Delhi Policy Group, New Delhi, India.
- Ecosystem approaches to human health and well-being: Illustrations of use in a mining context - Ligia Noronha (submitted to Ecohealth)
- Quality of life in mining regions; reporting from the field- Ligia Noronha and Subrahmanya Nairy (accepted for publication by Economic and Political Weekly (2004)

Abstracts accepted

- Mehra Y and Cooper S. **Trading health for work: A game theoretic model on collective action failure in the mining regions of Goa.** Ecological Sustainability and Human Well-Being. Ninth Biennial Conference of the International Society for Ecological Economics (ISEE), 15 – 18 December 2006, New Delhi, India.
- Cooper S. **(In Preparation).** Ecological Sustainability and Human Well-Being. Ninth Biennial Conference of the International Society for Ecological Economics (ISEE), 15 – 18 December 2006, New Delhi, India.

Book chapters

- Choudri B S and Chachadi A G. 2006. **Status of groundwater availability and recharge in the mining watersheds of North Goa**; in Multiple Dimensions of Global Environmental Change, pp. 623 - 649, edited by S Sonak, New Delhi, India: TERI Press. 726 pp.
- Cooper S, Mehra Y, and Joshi A. 2006. **Depletion of freshwater in the mining regions of Goa, India: gendered impacts and responses**; in Multiple Dimensions of Global Environmental Change, pp. 650 - 673, edited by S Sonak. New Delhi, India: TERI Press. 726 pp.

This project has contributed to building the strength of the research institute as well through tremendous capacity building and experience that has developed within the team. Additionally, through the project a variety of equipment and consumables were purchased as presented below:

Procurement of equipments and consumables

The following equipments and consumables were procured for this study

- SKC Make respirable personal air sampler pumps (2 Nos).
  Model number 224-PCXR 8
- SKC make Legand Legacy (air sampler with low and medium flow, suitable for personal and area sampling) – 2 no
- SKC Make PM10 impactors (4 Nos)
- Morgan Make Spirometer (1 Nos). Model: 232 pulmonary system
- Teflon filters 37mm (500 Nos)
- 2 laptops
- OHP
- HP Laser Jet 2300 series Printer
- Electronic balance
- Software (LIMDEP)
- Books and literature relevant to the study

Chapter 7: Recommendations, impacts and conclusions

This final chapter of the report is organised into three parts. The first section presents a summary of recommendations that have emerged from this study. The second section presents the team's assessment of impacts of the project activities within the mining ecosystem. Finally, the conclusion section presents the teams assessment of the value of the project as a whole.

A Recommendations

This section presents a summary of recommendations that emerge from this study. Recommendations have been organised into three sections. The first deals with management of natural resources and includes recommendations for land, water and air. The second focuses on recommendations that emerge for the health sector and specifically deals with health services and management of data generated through the health service network. The third section includes recommendations regarding capacity building for various stakeholders.

Management of natural resources

Land

Agricultural land and farmers

Reviving agriculture in the mining belt will require efforts on the part of all three stakeholders, namely companies, government and community. As described earlier, in Chapter 3, agricultural activity occurs within a system that is composed of interlinked components. Over time, these components of agriculture have been impacted by mining activities and have collapsed, making it necessary to simultaneously begin and continue a variety of initiatives to restart agriculture. This task will require a change in the approach being followed currently, as spelled out below:

- Reactive approach Proactive approach

Various government departments are involved in regulating agriculture as well as the mining industry. In the case of industry regulation, the departments tend to respond only after a problem has emerged. There is no proactive monitoring or support extended to companies to ensure their compliance with the law. Similarly, Agriculture and Water Resources departments tend to respond or intervene only when farmers complain. Despite knowing the impacts of mining, there are few if any, preventive measures taken or proactive assistance offered to farmers. These departments need to move from reacting to issues to responding proactively and taking a lead in planning and working with farmers and companies for better agriculture related outcomes.

In a similar vein companies need to take better environmental measures proactively rather than waiting for pressure from the community.

- Piecemeal approach Watershed approach

One of the most important conclusions from this research is the need for a watershed approach to reviving agriculture. It is clear that the practice of agriculture is a systemic whole composed of many parts that are interrelated and interdependent. In Goa, several overburden dumps are spread across the mining belt. The impact of erosion from these dumps is not limited only to adjacent areas but is felt in the lower reaches of the watersheds in which the dumps are located. Thus, planning for regeneration needs to done at the watershed or micro-watershed level. This would include:

  - Intensive dump management of all dumps within the micro-watershed
  - Desilting of water bodies from the upper reaches to the bottom of the micro-watershed and treatment of the drainage network to minimise transport of silt (eg. lose boulder check dams)
  - Desilting of fields and/or application soil amendments

- Independent (top down) planning Participatory (bottom up) planning

Government departments and mining companies alike, need to plan watershed activities mentioned above with the local community. Farmers usually have a detailed understanding of the land and water in their areas and can contribute significantly and effectively to any discussion on land management. Importantly, farmers need to have some sense of ownership over initiatives taken in their interest for these initiatives to work and be sustainable.

- Individual responses Integrated response

Currently, government departments involved in agriculture have little, if any, communication with each other. For example, Agriculture and Water Resource officers are well placed to identify dumps that are poorly maintained, but there is no interaction or feedback mechanism in place between them and regulatory authorities such as the IBM or SPCB. Similarly, there is very little coordination between Agriculture and Water Resources departments, despite the intimate connection between land and water in the context of agriculture. To have better outcomes these departments need to plan for action in coordination with each other.

- Compensation for land degradation

Currently, small amounts of compensation are paid for crop loss and for de-silting of land to farmers that approach companies. While this system has served as a disincentive to farmers to continue farming, it has not served as an incentive for better dump management.
The true cost of poor dump management needs to include not only the losses from decreased agricultural yields but also the cost of land degradation. We recommend compensation for land degradation as necessary because it will capture more accurately the loss born by farmers and it will force companies to spend more on environmental management and deter environmentally damaging practices.

Additionally, the Department of Agriculture should play a greater role in monitoring compensation payments since there is no government authority monitoring these compensations unless the amount is disputed.

Metal uptake in fruit crops

We have seen that cashew samples in the study showed significant positive relationship between metals in the soil system and in the plant system. On the other hand, mango samples did not show any relationship between the metals in the soil system and in the plant system. One of the main limitations of this study was the lack of sufficient fruit bearing trees growing on dumps because of which a sufficiently large number of samples were not available. As a result no generalisations can be made for the study area. However, since more than 40 plants show a statistically significant relationship between metal content in the soil and that in the plant system, there is a need to identify plants/trees that accumulate metals. Thus, detailed studies on a pilot basis are required to explore the possibility of metal uptake, if any, by the specific plants from the soil systems.

Water

Mining activities have had an impact on ground water bodies in the study area. To better address the impacts of mining on ground water resources, the following are recommended:

Ground water management

- More studies and more data generated on groundwater in the mining areas, both from an anthropocentric and an ecological point of view.
- Legislation on groundwater provides the authority to restrict groundwater withdrawals in ways that threaten drinking water sources and in watershed considered critical or overexploited. If a mining watershed is deemed critical it is not clear how this legislation will take affect without stoppage of mining activities. This issue needs to be addressed frontally leading to a clear policy.
- More data sharing regarding ground water and collaboration between departments in order to tackle this issue, specifically the Indian Bureau of Mines and the Department of Water Resources.

Alternative water supply

- In wards where alternative water supply is very poor or where tankers are the only source of water, more localised solutions need to be sought and invested in, such as rainwater harvesting.
- Water removed from mine pits could be treated and supplied to local communities.
- The suitability of abandoned or exhausted pits as water storage sites could be evaluated.
- More power and funding to Panchayats to address water supply problems at the local level
- Clear policy on action against landlords that prevent people's access to basic necessities like water

Air

In addressing air quality issues in the mining areas, we asked why, despite an extensive regulatory structure, air problem continued to persist. One of the major conclusions from this study was that the political-economy around mining and transportation and handling of ore created strong incentives to break existing laws. The deterrents to prevent illegal behaviour though, were weak. To effectively address this problem a holistic approach is required where all agents associated with transportation and handling of ore, namely government agencies, mining companies, financial institutions and truck owners, simultaneously act in order to mitigate the problem. Piece-meal and ad-hoc decisions will be insufficient and eventually ineffective. The following is recommended:

Mining companies

- A policy to stop overloading of trucks: Since trucks carrying ore are loaded within the mine, and since companies pay truck operators based on the tonnage carried, it is possible for mining companies to monitor the amount of ore loaded onto trucks. Mining companies need to formulate a "no-overloading" policy and ensure that it is adhered to by each of the trucks working for them. Such a proactive approach by companies will help reduce the pressure on air quality.
- Revision of transportation rates: It is clear from the research that at the current transportation rates paid by mining companies it is possible to break even only by overloading, which is the primary cause of air pollution and a breach of the law. Therefore, mining companies need to keep the ten-tonne limit in mind while calculating transportation rates, ensuring that it is possible to make profits while staying within the legally permissible loading limits.

Government

- Better enforcement of the law: Government agencies have a role in addressing the problem by better enforcement of the existing laws (related to better transport and handling practices and air quality control, monitoring and mitigation)
- Reviewing the penalty structure for overloading of trucks: As it exists, the penalty does not act as a strong enough deterrent on two accounts; firstly, the likelihood of being penalised is low and therefore the existence of the penalty is not a deterrent; secondly, the penalty structure is such that it encourages breaking the law with impunity providing incentives for truck operators to factor the penalty into costs and continue breaking the law. If transportation rates are raised but the fine structure remains unchanged, there will be a stronger incentive to break the law. Consequently, the structure of the fine needs to be revisited and revised upwards so as to make it a strong deterrent to legal violations and compliment other measures taken to regulate air quality.
- Regular monitoring and compilation of air quality data: While data on air quality within the mine lease exists, it is not in the public domain. Data on air quality outside the lease area, especially in road corridors, has historically not been generated. Only with the existence of regularly collect air quality data is it possible to regulate air pollution. We recommend regular monitoring and compilation of air quality data in mining regions, especially in high stress areas like road corridors, loading-unloading docks along rivers and settlements close to mines.

Financial institutions and banks

- Responsible lending: Lending for purchase of trucks has gained tremendous popularity in the recent past and there is great demand as well as supply for such loans. Financial agencies like banks that evaluate the profitability of the business, need to ensure that their profitability evaluation and terms of the loan provide, do not encourage breaking the law. Thus, while calculating profitability, a ten-tonne load per trip should be taken into account and not more.

Health

Health care services

This component of the study focused on an assessment of health care services in the study area. As communities in the mining regions face a variety of environmental stressors (especially poor air quality) that have an impact on health, the availability of health care services in the region play a crucial role in improving health outcomes in the mining areas. The following recommendations are based on the assessment of health care services taken up in the study area.

- An increased number of doctors (including specialists where needed) and paramedical staff are required in the mining region.
- Sub-centres need to be staffed with the prescribed two multipurpose health workers (MPHW) so that when one is out making home visits the centre can remain open. Additionally, the MPHWs need to cover a greater number of homes in order to improve preventive care in the region.
- The number of sub-centres in mining areas (specifically Bicholim /Sanquelim) needs to be increased in order to serve the population adequately. The use of mobile medical vans equipped with basic facilities could be considered in this context. Similarly, mobile vans could also be considered for parts of Cluster III that are remotely located and far from existing facilities.
- Some of the health care facilities in the mining regions need upgraded medical equipment such as basic operating instruments, X-ray machines, Pulmonary function tests equipment, echo cardiogram equipment, laproscopy etc. Additionally, staff qualified to use this equipment as well as analyse results need to be available.
- The public health care system could include more public outreach programmes that provide preventive care such as health camps for early detection of illnesses. This can be done in conjunction with local NGOs and private health care facilities.
- The community should be better informed about services available in the mining regions, including days of the week and timings of specific activities. Information on health care facilities and the services provided through the referral system should be available to users.

Data management

Research into data management in the health care system highlights the need for robust data on health status in order to track changes in health and respond effectively to health needs. The recommendations regarding health data management are presented below.

Implementation level

A variety of measures can be taken to improve functioning of the current system of data collection and management including the following:

- Assignment of data recording responsibility on particular staff members who are well trained to do the job
- Use of a computerised system to facilitate easy compilation and analysis
- Provision of a feedback based on data analysis to regional health centres in order to ensure that health centres can respond appropriately to health needs of the community. This feed back will also elicit better compliance from staff working at the lower levels because they will know the value of the data.
- Development of a system to ensure reporting from all health centres each month and to ensure proper data collection and compilation
- Provisions requiring all private health facilities to provide morbidity data
- Provision for filling of vacant posts related to data management

Policy level

At a policy level there needs to be some introspection on the current structure and function of data management in the state. A variety of issues merit consideration including the following:

- The purpose of general morbidity data gathering and the use of data generated through the system
- The need for more data analysis
- The need for identification of links between health status and environmental stressors such as mining
- Working in conjunction with other state government departments, such as the pollution control board to address environmental health issues
- The need for a state health policy that recognises the impact of environmental stressors on human health and recognises that these areas facing environmental stress may have special health care needs which need to be catered to.

Capacity building

This study has highlighted the need for capacity building within the local community and for government.

Local community

In order to ensure that local people have enough knowledge and awareness to contribute to decision making in a mining context. We recommend further capacity building for the following three groups of people:

Farmers groups

There are currently several farmers groups that limit their activities to collecting compensation from mining companies. In order to make these groups more effective and harness their power to bring about change/ revive agriculture these farmers groups need further capacity building that focuses on the following:

- Leadership skills
- Working in groups (group discipline, conflict resolution, group structure and functions etc.)
- Vision building and planning for agriculture (including experimentation with different crop varieties)
- Introspection about compensation (current pattern followed) and long-term thinking regarding degradation of a natural asset
- Developing an understanding of the government support system and linking with these agents
- Mobilising funds
- Dealing with mining companies
- Linking with markets

Micro-credit (Self –help groups)

Much like farmers groups, micro-credit groups also need capacity building in the initial stages. While several NGOs have been involved in forming new groups in the study area, very few of them have provided any training to group members following the initial set-up stage. Here we feel that to ensure the sustainability of the micro-credit/ self-help movement in the study area groups need to have ongoing training (group strengthening) and support over the initial two years.

We also recommend that Self-help groups be oriented towards more than just income generating activities and providing credit to members. Self-help groups have tremendous potential to be agents of change and a source of empowerment for women. To actually realise this potential groups need to be oriented towards taking up a variety of activities other than collecting money and giving loans.

Government

Local Government *(Panchayats)*

The governance component has highlighted the fact that local communities look to their Panchayats for solutions to a variety of problems that have emerged in the mining areas. On going training and capacity building programmes for elected representatives are recommended in order to ensure that they can perform their jobs more effectively. This would include general training on the following:

- Familiarisation with relevant legislation
- Leadership
- Participatory development
- Gender sensitisation

Additionally, programmes that are related to tackling specific problems in the mining areas are also recommended.

State Government Department representatives

Through interaction with state government representatives the research team has identified some issues that could be taken up for further capacity building:

- Further training to use the ESPI indicator tool
- Further sensitisation to community needs in the area

B Impacts of the project

This section highlights the impacts our project has had on the mining ecosystem. Across three phases of research this project has created opportunities for the research team to interact with all three stakeholders, namely companies, government and local communities. This interaction has taken place through qualitative research methods such as interviews, participatory rural appraisal exercises and group discussions and extensively through capacity building work. Additionally, efforts have been made in each phase of the research to disseminate information about the project and the key findings through multi-stakeholder workshops. Over time this has undoubtedly had an impact on the stakeholders involved. It is important to mention here that we recognize that an ecosystem is a complex system where several factors, agents and incidents influence outcomes and that our effort at creating sustainability in the mining ecosystem is but one such force of change amongst several. While we cannot claim to be the sole reason for changes in the behaviour of people, attitudes and outcomes, we can confidently say that the project has influenced the direction of change taking place in the study area.

Importantly, TERI has taken up other projects in the mining areas which helped us build networks between different groups of people. This has played a significant role in extending the reach of this project and helping create sustainable impacts. Through examples we attempt to discuss the reach and impact our project has had.

Empowerment at the local level

Several incidents and events at the local level involving community members we have worked with indicate greater level of empowerment and control. For example, two self-help groups (in the same village) we have engaged with over the course of the project, called a meeting and invited their local elected representatives to the meeting. At this meeting they demanded to know why they had no tap water supply and requested their Pancha to look into the matter.

Similarly, a farmers group we have worked with got together to stop construction of a bridge as they felt it would interfere with the drainage network supplying water to their fields. At one of the Women' s Gram Sabha programmes[1] recently conducted women discussed the lack of health care facilities near their village. By the end of the meeting they had drafted a letter asking their Panchayat to approach higher authorities regarding this matter. Additionally, a few days later, 18 of these women got together, hired a mini-van and went to their village assembly at the Panchayat for the first time.

In terms of empowerment we have specifically noticed the following:

- Increased confidence among women and farmers regarding their ability to address issues of concern to themselves
- Better understanding of how to move government machinery for redress
- More faith in the government mechanism

[1] The main objective of having women's Gram Sabha meetings a few days before the actual village Gram Sabha is to encourage women to attend their village assembly.

- Awareness about the need for networking and dialogue with government officials and other civil society members with similar experiences

We acknowledge that these are small victories, however, collectively they point to a change in attitude and a sense empowerment at the local level.

Better attitude towards problems in the region and towards other stakeholders

Through regular interactions with mining companies we have noticed a change in their attitude towards discussing the impacts of mining. They are more open to acknowledging problems and are much more willing to engage with the community to solve these problems. An example of this is the farmers visit to the mine dumps. Five companies provided a tour of their dumps to a small group of farmers accompanied by TERI researchers. This served as a trust building exercise for both stakeholders.

Discussion and dialogue

Various formal and informal meetings and workshops held through this project have provided opportunities for discussion and dialogue. This is especially important for government departments as they usually work in isolation and have very formal interactions with one another. Through our project, we helped create forums where different government departments and officials could interact with another in informal settings where they could freely express their apprehensions and concerns.

Another important contribution of the project in this regard has been to bring community perceptions and perspectives on various topics ranging from agriculture, health, livelihood issues etc to the mining companies. For example, mining companies feel that all farmers are not interested in agriculture and would rather have mining or related jobs. Through our research we have tried to explore this stereotype and determine to what extent this is true. We found that while there were a number of farmers who were not too keen on farming, there were as many who would prefer to continue with agriculture if it were possible. Having understood how poorly managed dumps impact the entire agricultural system and how this makes continuing agriculture in the face of poor dump management practices a losing battle, we have been able to share our insights and community perspectives with companies, who are then in a better position to make decisions regarding supporting agriculture, compensation etc.

Increased exposure to new ideas

By including company, government and other NGO representatives in exposure visits and capacity building programmes the project has helped to build knowledge and innovative thinking that is useful to stake holders.

Recognising that the Minerals Foundation (MF – an industry funded foundation) and local government departments will have a continuous presence in the mining areas, we felt it was important to include them in the various components of our project. We ensured they accompanied us for the various exposure visits, both within and outside of Goa. They were also a part of the Social Analysis Systems workshop, where they learnt various social analysis techniques.

C Conclusions

In the following concluding remarks we present the teams assessment of this project.

The principles of the Ecohealth approach and the focus on simultaneously exploring the links between several domains within an ecosystem have guided this study through three phases. This approach has provided the space required to understand the breadth of issues that determine well-being.

Phase III, including components on health, land, gender and governance, has highlighted some of the failures in terms of natural resource management in the study area. This has emerged very clearly in the context of air quality, land quality and water quantity. Studies have also shown how the impacts of natural resources have affected health and well-being of the community in terms of bio-medical health, livelihood opportunities and access to basic needs.

While mining has contributed to economic growth in the region through the creation of employment for a large percentage of the population, it has also led to a loss of employment opportunity in other sectors (agriculture). Left with a degraded natural resource base and without adequate skills to diversify into non-traditional activities, the local community has been pushed towards a strong dependence on mining for employment. As a result the community is more willing to trade off their health and well-being for work/income. Studies also show that women bear a large proportion of these negative impacts. Their gender roles have confined women to the home and the farmstead making them more dependent on natural resources and therefore more vulnerable to changes in nature. Simultaneously, their gender roles prevent women from actively participating in civic life, curtailing their ability to respond to changes that profoundly affect their lives.

The governance component of this study has characterised the roles of each of the key stakeholders, namely companies, communities and government, in responding to environmental and social changes in the region. It highlights the need for improved decision making that is based on a better understanding of changes in the region. The lack of information/ data emerging from the region and the community's inability to access what is available has led to limited and unsustainable responses.

Collectively, these findings have only underlined the need for the tools developed in Phase II to track sustainability and well-being in mining regions. The third phase of research has also focused on refining the three tools, namely Environmental and social performance indicators (ESPI), the Quality of life (QoL) survey and Impact adjusted income accounts. While these tools are meant to support decision making for companies and government, the capacity building programmes undertaken in this project mark the beginning of a process of empowerment within the local community. The capacity building work has focused on helping community members to respond more effectively to changes in their environment and to have more control over their health and well-being.

As the demand for metals grows globally to keep pace with expanding economies the mining industry in India is likely to expand over the next decade. In this context, the use of the three tools intended to track health, well-being and sustainability will help temper or balance expectations of high economic growth through a better understanding of well-being.
In the Goan context, dissemination of research findings emerging from the study has put valuable information regarding the impacts of mining into the public domain pushing stakeholders to engage with these issues.

This project has generated valuable data on the links between air pollution and respiratory health and on the economic costs of respiratory ill-health in the study area. The research methodology and analysis for these components has taken a bulk of the 3.5 year project period. As these findings have just been disseminated and further dissemination work is required the impact of these findings will emerge over time.

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Annexures

Annexure A

24-hour PM10 concentration in ambient air....2
Reported health problems across clusters....3
Structure and functions of public health care services....4
Economic model of health and air pollution....5
Health survey questionnaire
Common household questionnaire....10
Specific individual questionnaire....15
Recall questionnaire....22
Health diary....23

Annexure B

A Crop preferences through matrix ranking....25
B Summary of discussion on costs and benefits....27
C Metal estimation
Estimation of metal content in soil and biological samples in mg/kg 28
Estimation of bio-available metals in the soil system in mg/kg....31

Annexure C

A Governance in the context of air quality in mining areas....33
B Governance case study: Responses to changes in ground water and shortages of water for household use....47
C Health data management case study....66
D Format for communicable diseases....73
E Format for non-communicable diseases (general morbidity) data....74
F Governance questionnaire....75

Annexure D

Revised QoL tool....77
Environment and Social Performance Indicators (Companies)....85
Environment and Social Performance Indicators (Government)....89

Annexure A

Contents

24-hour PM10 concentration in ambient air 2
Reported health problems across clusters 3
Structure and functions of public health care services 4
Economic model of health and air pollution 5
Health survey questionnaire
Common household questionnaire 10
Specific individual questionnaire 15
Recall questionnaire 22
Health diary 23

24-hour average PM_{10} concentration in ambient air

Cluster	Village	PM_{10} Conc.
I	Piligao	205
I	Piligao	256
I	Piligao	184
I	Piligao	326
II	Pisserlum	144
II	Pisserlum	172
II	Pisserlum	347
II	Pale	395
II	Pale	328
II	Surla	534
II	Surla	159
III	Sanvordem	206
III	Sanvordem	362
III	Codli	236
Road Corridor	Curchorem	436
Control	Rivona	71

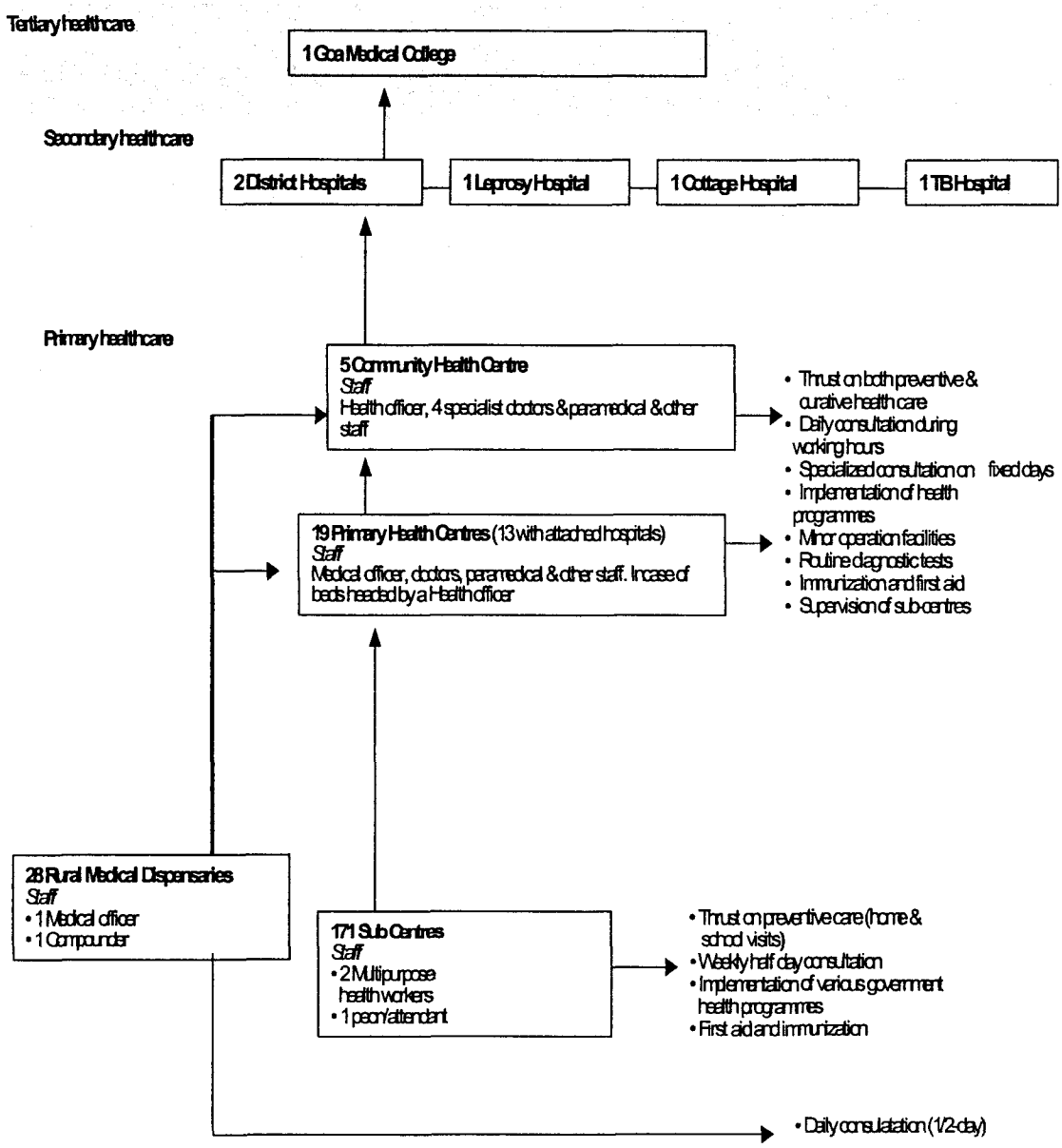
Annexure A

Reported health problems across clusters and gender (in percentages)

Health issues	Cluster I			Cluster II			Cluster III			Corridor			Control		
	M	*F*	*T*	*M*	*F*	*T*	*M*	*F*	*T*	*M*	*F*	*T*	*M*	*F*	*T*
Headache	35	39	37	39	48	43	31	44	38	20	40	29	29	41	35
Fever	29	30	29	34	28	31	29	34	31	24	29	27	28	35	31
Eye irritation, tears, allergy	24	14	20	24	28	26	25	19	22	18	27	22	18	27	22
Nose irritation, allergy	9	14	11	9	12	10	13	12	12	12	9	11	11	11	11
Cold, sinus	52	62	57	65	63	64	61	60	61	59	56	57	64	66	65
Throat irritation, dry scratchy throat, sore throat	18	18	18	19	24	22	20	23	21	20	19	19	13	26	19
Hoarseness of voice	12	14	13	12	11	12	18	20	19	13	16	14	13	31	22
Skin infection, rashes, boils	7	5	6	6	6	6	13	8	10	13	13	13	17	13	15
Skin irritation, allergy	9	1	5	5	6	6	5	7	6	3	12	7	11	6	9
Respiratory problems	5	1	3	8	10	9	12	8	10	13	16	14	9	9	9
Dust allergy	18	12	15	31	25	28	23	20	21	22	27	24	11	19	15
Dry cough	29	21	25	29	26	27	31	26	29	36	35	36	40	39	40
Cough with phlegm	9	12	10	15	14	15	13	14	13	17	12	14	11	10	10
Shortness of breath	6	5	6	7	9	8	11	10	10	11	12	11	13	12	12
Wheezing	3	4	3	7	10	9	6	8	7	7	10	9	7	10	9
Bronchitis	1	0	1	3	1	2	1	0	0	0	2	1	1	0	1
Asthma	0	1	1	3	6	5	2	5	3	1	1	1	4	4	4
TB	2	0	1	1	0	0	1	0	0	0	0	0	1	1	1
Heart problems	2	0	1	4	1	3	3	3	3	3	1	2	2	3	3
Chest pain	9	7	8	6	6	6	6	6	6	10	6	8	5	11	8
High blood pressure	2	5	3	7	3	5	7	5	6	9	13	11	4	16	10
Other illness	18	14	16	22	16	19	21	22	21	21	21	21	27	27	27
M = male, F = female, T = total															

Annexure A

Structure and functions of public health care services



Economic model of health and air pollution

The economic model to value health costs of air pollution was developed using total exposure assessment and the agricultural model. The theoretical model is described in detail below.

$U = U(S, C_X, t_L)$ (1)

Utility is a function of S, sick-days, C_X, other goods consumed, and t_L, which is time for leisure.

$S = S(E, N, D)$ (2)

Sickdays is a function of exposure, E, nutrition, N, and visits to the doctor, D.

$E = (e_o t_o + e_h t_h)$ (3)

Total exposure equals the sum of concentration in different microenvironments (denoted by e) multiplied by the time spent in the these different microenvironments (denoted by t). To keep the analysis tractable, we restrict ourselves to two microenvironments, outdoor, denoted by the subscript o, and home, denoted by the subscript h.

The outdoor concentration is an exogenous variable for the household.

$e_h = e_h(b_{FW}, k)$ (4)

The concentration in the home microenvironment, e_h, is a function of the consumption of fuel, here assumed to be fuelwood, b_{FW}, and of the fuel, stove and kitchen characteristics, denoted by k. Although we are assuming that fuelwood is the cooking fuel, this does not affect the generality of the results.

$N = N[b_{FW}, C_N, t_h]$ (5)

Cooked food, or nutrition, N, is a function of the cooking fuel used, grain consumed, C_N, and time spent cooking, t_h.

The budget constraint of the household is given by

$I + t_w p_w = p_{FW} b_{FW} + p_N C_N + p_X C_X + p_D D$ (6)

Where I is exogenous income, t_w is time spent working. Prices are denoted by p, with p_w the wage rate, and other subscripts denoting the type of price.

The time constraint of the household is given by

$T = t_w + S + t_L + t_h$

Where T denotes total time, t_w time working, S is sickdays, L is leisure and h is home. We assume that work is done outdoors, leisure is outdoors, and all time at home is spent cooking. We discuss the implications of relaxing these assumptions after deriving the results using these simplifying assumptions.

After substituting for t_w from the time constraint into the budget constraint, we write the Lagrangian as:

$$J = U[C_X, t_L, S(E, N, D)] + \lambda [I + p_w [T - S - t_L - t_h] - p_{FW} b_{FW} - p_N C_N - p_X C_X - p_D D] \quad (7)$$

The first order conditions are listed below.

$$\frac{\partial J}{\partial t_L} = \frac{\partial U}{\partial t_L} + \frac{\partial U}{\partial S}\frac{\partial S}{\partial E}e_o - \lambda\, p_w \frac{\partial S}{\partial E}e_o - \lambda p_w = 0 \quad (8)$$

$$\frac{\partial J}{\partial t_h} = \frac{\partial U}{\partial S}\frac{\partial S}{\partial E}e_h + \frac{\partial U}{\partial S}\frac{\partial S}{\partial N}\frac{\partial N}{\partial t_h} - \lambda\, p_w \frac{\partial S}{\partial E}e_h - \lambda\, p_w \frac{\partial S}{\partial N}\frac{\partial N}{\partial t_h} - \lambda p_w = 0 \quad (9)$$

$$\frac{\partial J}{\partial bFW} = \frac{\partial U}{\partial S}\frac{\partial S}{\partial E}\frac{\partial e_h}{\partial b_{FW}}t_h + \frac{\partial U}{\partial S}\frac{\partial S}{\partial N}\frac{\partial N}{\partial b_{FW}} - \lambda\, p_w \frac{\partial S}{\partial E}\frac{\partial e_h}{\partial b_{FW}}t_h - \lambda\, p_w \frac{\partial S}{\partial N}\frac{\partial N}{\partial b_{FW}} - \lambda\, p_{FW} = 0 \quad (10)$$

$$\frac{\partial J}{\partial C_N} = \frac{\partial U}{\partial S}\frac{\partial S}{\partial N}\frac{\partial N}{\partial C_N} - \lambda\, p_w \frac{\partial S}{\partial N}\frac{\partial N}{\partial C_N} - \lambda p_N = 0 \quad (11)$$

$$\frac{\partial J}{\partial C_X} = \frac{\partial U}{\partial C_X} - \lambda\, p_X = 0 \quad (12)$$

$$\frac{\partial J}{\partial D} = \frac{\partial U}{\partial S}\frac{\partial S}{\partial D} - \lambda\, p_w \frac{\partial S}{\partial D} - \lambda p_D = 0 \quad (13)$$

In first order condition (8), $\frac{\partial U}{\partial t_L}\frac{1}{\lambda}$ is the rupee value of utility arising from additional leisure time. $\frac{1}{\lambda}\frac{\partial U}{\partial S}\frac{\partial S}{\partial E}e_o$ is the rupee value of disutility caused by an additional sick day due to an additional unit of exposure to air pollution. p_w is the rupee value of the opportunity cost of time spent on leisure, time that could be spent working. $p_w \frac{\partial S}{\partial E}e_o$ is the opportunity cost of time due to the additional sickness arising from an additional unit of exposure to outdoor air pollution.

The indirect utility function can be used to value the health benefits from a reduction in pollution (Harrington and Portney 1987, Freeman 1993). The optimal values for the choice variables t_L, t_h, b_{FW}, C_N, C_X, D depend on the parameters I, p_w, p_{FW}, p_N, p_D, e_o and k. Thus the indirect utility function can be expressed as
V(I, p_w, p_{FW}, p_N, P_D, e_o, k)

The marginal willingness to pay for a reduction in air pollution is:

$$w_{e_o} = \frac{dI}{de_o} = -\frac{\partial V / \partial e_o}{\partial V / \partial I} = -\frac{\partial V / \partial e_o}{\lambda} \qquad (14)$$

$$\frac{\partial V}{\partial e_o} = \frac{\partial U}{\partial S}\frac{\partial S}{\partial E}t_w + \frac{\partial U}{\partial S}\frac{\partial S}{\partial E}t_L - \lambda\, p_w \frac{\partial S}{\partial E}t_w - \lambda\, p_w \frac{\partial S}{\partial E}t_L$$
$$= \left(\frac{\partial U}{\partial S} - \lambda\, p_w\right)\left(\frac{\partial S}{\partial E}\right)(t_w + t_L) \qquad (15)$$

Our expression for w_{eo} differs from that derived by Freeman (1993) only in that it is multiplied by t_o (=t_w + t_L).

The household can adjust its choice variables in such a manner that the marginal gains in terms of benefits from reduced sickness match the marginal costs of adjusting the choice variables. For example, in the case of doctor visits:

$$w_{e_o} = -p_D \frac{(\partial S / \partial E)}{(\partial S / \partial D)}[t_w + t_L] \qquad (16)$$

we get this expression from equations (13) and (15).

Following Harrington and Portney (1987) and Freeman (1993), we derive an alternative expression for the willingness to pay to avoid outdoor air pollution. To do so, we take the total derivative of the health production function.

$$\frac{dS}{de_o} = \frac{\partial S}{\partial E}\frac{\partial E}{\partial e_o} + \frac{\partial S}{\partial E}\frac{\partial E}{\partial t_o}\frac{\partial t_o^*}{\partial e_o} + \frac{\partial S}{\partial E}\frac{\partial E}{\partial b_{FW}}\frac{\partial b_{FW}}{\partial e_o} + \frac{\partial S}{\partial E}\frac{\partial E}{\partial t_h}\frac{\partial t_h^*}{\partial e_o}$$
$$+ \frac{\partial S}{\partial E}\frac{\partial D^*}{\partial e_o} + \frac{\partial S}{\partial N}\frac{\partial N}{\partial C_N}\frac{\partial C_N^*}{\partial e_o} + \frac{\partial S}{\partial N}\frac{\partial N}{\partial b_{FW}}\frac{\partial b_{FW}^*}{\partial e_o} + \frac{\partial S}{\partial N}\frac{\partial N}{\partial t_h}\frac{\partial t_h^*}{\partial e_o} \qquad (17)$$

In equation (17) we can now move the term $\frac{\partial S}{\partial E}\frac{\partial E}{\partial e_o}$ to one side of the equal sign, and dS/de_o to the other side. Multiplying the equation by the term $\left(\frac{-1}{\lambda}\frac{\partial U}{\partial S} + p_w\right)$ and substituting from the first order conditions we get equation (18).

The first order equations can be re-organized as follows. Equation 8b corresponds to the first order condition in equation (8), and so on.

$$\left(-\frac{1}{\lambda}\frac{\partial U}{\partial S}+p_w\right)=\frac{-p_w+(\partial U/\partial t_L)(1/\lambda)}{(\partial S/\partial E)e_o} \qquad (8b)$$

$$\left(-\frac{1}{\lambda}\frac{\partial U}{\partial S}+p_w\right)=-p_w\left(\frac{\partial S}{\partial E}e_h+\frac{\partial S}{\partial N}\frac{\partial N}{\partial t_h}\right) \qquad (9b)$$

$$\left(-\frac{1}{\lambda}\frac{\partial U}{\partial S}+p_w\right)=-p_{FW}\left(\frac{\partial S}{\partial E}\frac{\partial e_h}{\partial b_{FW}}t_h+\frac{\partial S}{\partial N}\frac{\partial N}{\partial b_{FW}}\right) \qquad (10b)$$

$$\left(-\frac{1}{\lambda}\frac{\partial U}{\partial S}+p_w\right)=-p_N\left(\frac{\partial S}{\partial N}\frac{\partial N}{\partial C_N}\right) \qquad (11b)$$

$$\left(-\frac{1}{\lambda}\frac{\partial U}{\partial S}+p_w\right)=-p_N\left(\frac{\partial S}{\partial D}\right) \qquad (13b)$$

$$w_{e_o}=p_w\frac{dS}{de_o}-\frac{1}{\lambda}\frac{\partial U}{\partial S}\frac{dS}{de_o}+p_D\frac{\partial D^*}{\partial e_o}+p_w\frac{\partial t_o^*}{\partial e_o}-\frac{1}{\lambda}\left(\frac{\partial U}{\partial t_L}\right)\frac{\partial t_o^*}{\partial e_o}+p_{FW}\frac{\partial b_{FW}^*}{\partial e_o}+p_w\frac{\partial t_h^*}{\partial e_o}+p_N\frac{\partial C_N^*}{\partial e_o} \qquad (18)$$

Because our health production function has more elements than Harrington and Portney's (1987) or Freeman's (1993), so does the expression for willingness to pay. The top line shows the expressions that are also there in Harrington and Portney (1987), and Freeman (1993)—the lost earnings, direct disutility of sickness, medical expenses, and the averting costs (which in this model is the costs of adjusting time indoors and outdoors). In addition, there is the cost of adjusting fuel consumption, and consumption of grain, in the bottom line.

The concentration of air pollution outdoors, e_o is a public good—it is given for a set of households, and they are all affected by outdoor air pollution in the area to which they belong. An improvement in outdoor air quality would lead to total benefits equal to the sum of willingness to pay of individuals in households which live in that area.

Indoor air pollution is a private good—it affects the household alone. Strictly speaking, there is some externality from cooking emissions to neighbouring households, but indoor air pollution is largely a private good. The indoor air exposure is a function of k, which denotes stove and kitchen design, essentially capturing the conversion of fuel into particulate concentration in the household. We now examine the household's willingness to pay for a change in k.

Proceeding like we did for outdoor air pollution, we get equation (19).

$$w_k = p_w \frac{dS}{dk} - \frac{1}{\lambda}\frac{\partial U}{\partial S}\frac{dS}{dk} + p_D \frac{\partial D^*}{\partial k} + p_w \frac{\partial t_o^*}{\partial k} - \frac{1}{\lambda}\left(\frac{\partial U}{\partial t_L}\right)\frac{\partial t_o^*}{\partial k} + p_w \frac{\partial t_h^*}{\partial k} + p_{FW} \frac{\partial b_{FW}^*}{\partial k} + p_N \frac{\partial C_N^*}{\partial k} \quad (19)$$

Discussion of relaxing some assumptions

So far, we have assumed a kind of representative household member. Typically, the household would have adult males and females and children. We can think of a household welfare function with weights on adult male (superscript M), adult female (superscript F), and children's (superscript C) health (alpha is a weight and S is sickness)

$$U_H = U_H(\alpha^M S^M, \alpha^F S^F, \alpha^C S^C, t_L^M, t_L^F, C_X) \quad (20)$$

Typically, the household would behave as though $\alpha^C > \alpha^M > \alpha^F$. Since adult females are likely to be doing the cooking, they experience the greater share of exposure to indoor air pollution. So would children. Women would also bear the burden of looking after the sick, a point we will return to.

We have assumed that the household knows about the effects of air pollution and adjusts its choices accordingly. However, it may underestimate the health effects of indoor air pollution. If decision making is mainly in the hands of men, and women experience the consequences, then the feedback from indoor exposure to decisions about fuel and stoves will be diluted.

We have used a simple function for exposure to keep the analysis tractable. However, we can think of a more detailed version:

$$E = t_o e_o + t_{comm} e_{comm} + t_w e_w + t_h e_h + t_{cook} e_{cook} \quad (21)$$

where 'comm' stands for commuting and 'cook' for cooking. Exposures in the home, e_h, would be influenced by both cooking and by outdoor air pollution. Commuting exposures could be high. So could exposures at the workplace, especially for mining workers.

We have assumed that the household works for a wage, that cooking fuel is bought and that when there is sickness the household would choose to pay for medical expertise. However, the household could carry out production itself, it could gather fuel, and it could use traditional medicine. These actions would have an opportunity cost in terms of time.

Annexure A

Code:
Serial number:

Common Household Questionnaire

Identification information: (to be filled by investigator)

Identification Number:_____ Date: _____/_____/_____

Name of the interviewers: _____

House Number:_____ Ward: _____

Village: _____ Taluka:_____

Time: Start :_____ End:_____

I. Socio-economic status of the household

1. Are you originally from this village?

   (1) Yes ☐ ☞Go to 5 (2) No ☐ ☞Go to 2

2. Which year did you come to this village? _____

3. Reason for coming to this village: _____

4. Place of origin: _____

5a. Religion: _____

5b. Caste: _____

6. Type of family (1) Joint ☐ (2) Nuclear ☐

7. Size of the household (from the SE table): _____

8. Number of women in the HH (from the SE table): _____

9. Total family income per month: Rs_____

10. Total family expenditure per month: Rs._____

II. Housing characteristics

1. Type of house (Observation by the interviewer)

   (1) Pucca (2) Semi- pucca (3) Kutcha

2. Floor of residence: _____

3a. Total number of rooms: _____

3b. Total area of the house: _____(if they know)

4. Distance from the main road: (meters)_____

5. Distance from the mine site: (meters)_____

6. How many windows do you have at your house? _____

7. Is the house electrified? (1) Yes ☐ (2) No ☐

8. What are the other sources of light at home?

(1) Kerosene lamps (2) Gas lights (3) Oil (4) Candles

(5) Others (specify)_____

9. How do you dispose your solid waste?

(1) Burning (2) Throwing it in open places/river/forests

(3) Manure/compost (4) Open pits panchayat/private

(5) Closed pits (private) (6) Others_____

10. Do you use coils or incense or any other repellants to ward off insects/ mosquitoes?

(1) Yes ☐ (2) No ☐

11. If yes, for how many months in a year do you use it? _____

III. Kitchen: indoor smoke exposure

1. Who cooks the food in your house? _____

2. .How many meals do you cook in a day?_____

(1) One ☐ (2) Two ☐ (3) Three ☐

3. Type of fuel and stove used for cooking and water heating (tick mark in the appropriate column and write the codes for the type of stoves as given below the table)

Type of fuel	Purpose		Type of stove	
	Cooking	Heating	Cooking	Heating
Wood				
Twigs/branches/crop residues				
Dung cake				
Kerosene				
LPG				
Electricity				
Biogas (gobar)				
Any others				

Types of stoves
1.Mud or clay without chimney 2. Mud or clay chula with chimney 3. Three stones 4. Kerosene stove
5. Biogas stove 6. LPG stove 7. Bumba 8.Other (specify)

4. IF LPG/ is in use, since how long are you using this? _____ years

5. How many days does one cylinder last? _____days

6. Type of kitchen (For indoor cooking/water heating to be observed and tick marked in the appropriate column by the investigator)

Activity	Type of kitchen	Rainy season	Other season
Cooking	Separate room inside the house with a door/without a door		
	Inside the house but not a separate room		
	Separate room/place outside the house		
Water heating	Separate room inside the house with a door/without a door		
	Inside the house but not separate room		
	Separate room/place outside the house		

7. How do you cook?

(1) Standing
(2) Sitting/bending/kneeling

8. Number of windows in the kitchen: _____

9. Do you use exhaust fans/chimney in the kitchen?

(1) Yes (2) No

IV. Health

1. Who pays for your medical expenses?

(1) Employer (2) Self (3) Partly employer

2. **If (3)** then what is the percentage contribution by the employer?_____

3. How many members in your family have health insurance?_____

V. Averting activities

Do you/your HH members avoid walking and disallow children from playing outside due to such pollutants?

(1) Yes (2) No

Has any other activity of the household been changed to avoid dust exposure?

(1) Yes (2) No

3. Do you close the windows or doors of your house to avoid dust?

(1) How many hrs in a day? _____ (2) Which months? _____

4. Do you have plants and trees in your garden or compound?

(1) Yes (2) No

5. Any other averting measures used by your HH to avoid dust?

_____

Completely fill in the socio economic table and the specific individual questionnaire for each and every member of the household.

Socio-economic status of the individuals in the HH.

Ensure that ALL the members of the HH are listed here. Circle the respondent(s) of the common HH questionnaire.

Sl. No	Individual members	Relation to head of HH	Age	Sex	Marital Status	Education	Present occupation	Past occupation (if different from present)	Reason for change in occupation (in case of a change)	Other occupations (if any)

If any family members are working abroad, income/month of their remittances

Size of the HH: ____ Number of women/girls in the HH: _____(count from the table)

Annexure A

Code:
Serial number:

Specific Individual Questionnaire

Identification information: (to be filled by investigator)

Identification Number: _____ Date: _____/_____/_____
Name of the Interviewers: _____
House Number: _____Ward: _____
Village: _____ Taluka: _____
Time: Start: _____ End:_____

Part I:

1. Name of the individual: _____

2. Number of years staying at this address: _____

3. Where did you live before this? _____

4. For how long (years)? _____

Part II:

1. How often do you travel to school/work/market?

(1) Everyday (2) Alternate day (3) Every week

(4) Once in 15 days (5) Any others_____

2. How do you usually get to work/school/college? **(Tick one or more)**

1) Bus
2) Train
3) Lorry/truck
4) Car/Jeep/Van
5) Auto/Tempo
6) Scooter/Motor cycle
7) Bicycle
8) On foot

3. What are your work/school/college timings?

From _____ to _____

4. Where is your place of work/study located (address)? _____

5. Are you regularly exposed to any kind of irritants such as dust, smoke or fumes at work/study/home?

(1) Yes (2) No

6. Do you work indoors? (1) Yes (2) No

If **Yes**, where? **(Tick the response)**

1) Shop
2) Office
3) Factory (Please specify) _____
4) Other (Please specify) _____

7. Do you work outdoors? (1) Yes (2) No

If **Yes**, where? _____

8. If you had another job earlier, did you have a similar exposure in your previous job? **(Only if applicable)** (1) Yes (2) No

9. How much time do you spend in the kitchen?

(1) Actual time cooking _____hours

(2) Other than cooking _____hours

10. Do you do exercises? (1) Yes (2) No

11. Smoking status

1) Never smoked
2) Ex-smoker
3) Current smoker

If ex-smoker or current smoker, continue with the following questions

If nonsmoker, go to Part – III

12. What do you or did you smoke?
1) Bidis
2) Cigarettes
3) Hukka
4) Others (please specify) _____

13. At what age did you start smoking? _____

14. How many bidis/cigarettes etc do you smoke or used to smoke every day?

Minimum _____ Maximum _____

15. If ex-smoker, reason for stopping and when stopped: _____

Part III: Fill in the days of sickness for each illness during the past 3 months

Have you suffered from any of the following illnesses?	Yes	If Yes, have you suffered from this during the last 3 months	How many days were you sick due to this illness in the last 3 months
1. Headache			
2. Fever			
3. Eye irritation, tears, allergy			
4. Nose irritation, allergy			
5. Cold, sinus			
6. Throat irritation, dry scratchy throat, sore throat			
7. Hoarseness of voice			
8. Skin infection, rashes, boils			
9. Skin irritation, allergy			
10. Respiratory problems			
11. Dust/pollen allergy			
12. Dry cough			
13. Cough with phlegm			
14. Shortness of breath			
15. Wheezing			
16. Bronchitis			
17. Asthma			
18. TB			
19. Heart problems			
20. Chest pain			
21. High blood pressure			
22. Any other illness (specify)			

Part IV: Questions related to respiratory symptoms

A) Cough

1. Do you frequently get a cough? **(Exclude clearing of throat)** (1) Yes (2) No

2. Do you usually cough when you get up in the morning? (1) Yes (2) No

3. Do you usually cough at other times during the day or night? (1) Yes (2) No

If "No" to (1,2, or 3), go to "C"

If "Yes" to (1,2 or 3), ask the following questions:

4. Do you cough like this on most days for 3 months or more during the year?

(1) Yes (2) No

5. In which season do you get cough more often **(tick the response):**

1) Winter
2) Summer
3) Rains
4) Same in all seasons

B) Phlegm

6. Do you frequently bring up phlegm or sputum from your chest? (1) Yes (2) No

7. Do you usually bring up phlegm or sputum from your chest when you get up in the morning? (1) Yes (2) No

8. Do you usually bring up phlegm or sputum from your chest at other times during the day or night? (1) Yes (2) No

9. Do you usually bring up phlegm or sputum from your chest on most days for as much as 3 months in a year? (1) Yes (2) No

C) Shortness of breath

10. Do you get short of breath when you hurry (walk fast) on level ground or walk up a slight incline? **(Distinguish from fatigue)** (1) Yes (2) No

11. Do you get short of breath walking with other people of your age on level ground? (1) Yes (2) No

12. Do you have to stop or reduce your pace to catch breath? (1) Yes (2) No
If "No" to any of the above, go to "D"

If "Yes" to any of the above, ask the following question:

13. In which season do you get short of breath more often **(encircle the response):**

1) Winter
2) Summer
3) Rains
4) Same in all seasons
5) Change of seasons

D) Wheezing

14. Do you ever get wheezing of whistling sound in your breathing?

(1) Yes (2) No

If "No" to (14), then go to "E"

If "Yes" to (14), please ask the following questions:

15. Did you ever get wheezing or whistling sound in your breathing?

During the: **(tick the response)**

1) Last week
2) Last month
3) Last 3 months
4) Last 6 months
5) Last 1 year

16. Does this wheezing or whistling sound occur: **(encircle the response)**

1) After a "cold"? (1) Yes (2) No

2) After running or severe exercise or intense exertion? (1) Yes (2) No
3) When you are exposed to dust/ smoke/ strong fumes/ smells? (1) Yes (2) No

4) When the weather or season changes? (1) Yes (2) No

17. During the past two years have you had any chest illnesses that have kept you off work, indoors at home or in bed? (1) Yes (2) No

18. Have you ever had or do you currently have any chronic heart or chest disease?

(1) Yes (2) No

(Chronic means disease of long duration)

Part V: Occupational health

1. Does your job involve contact with metals, chemicals, liquids or solvents?

(1) Yes (2) No

2. What are the problems you face at your work place with regard to air, water, noise, humidity, temperature, facilities or any others? (write the kind of problems they face at work, e.g. poor ventilation, unsafe water, loud noise, extreme dryness, heat, cold, poor lighting, poor work space, faulty equipments ect)

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3. Are you exposed to allergens like irritants, pollens, mould, droppings, dust mite, pets, wool, cotton? (1) Yes (2) No

4. Do you use safety devices at work like eye goggles, face mask, gas mask, hearing cover, or headgear, if required for your job? (1) Yes (2) No

5. Did you have or are you having any health problems while at work?

If yes, what kind of health problems do you have?

Part VI: Mitigating activities

1. State individual expenditure incurred towards your medical costs in the last 3 months.

Individual Expenditure	Last 3 months
1) Number of visits to the doctor	
Disease details	
2) Expenditure on a) Doctor's fees b) Pharmacy/medicines c) Diagnostic tests d) Hospitalisation e) Travel f) Any others	
3) Number of days hospitalised	
4) Number of days of work lost due to illness	
5) Number of days of work lost due to illness of family members	

2. Local mitigation measures

2a. Do you undertake any home remedies for respiratory problem?

E.g. herbs, honey, onion juice, dry ginger, tulsi, kashay, gangan, shoonthi, badishee, others

(1) Yes (2) No

3. How much do you spend per month on such measures? Rs. _____

Part VII: Awareness and averting activities

1. Are you aware that air pollution causes illness? (1) Yes (2) No

2. What are common illnesses that could be caused due to air pollution in your village?

_____

3. Have you/ your family members suffered from any of the above illness during the last one year?
(1) Yes (2) No

4. How many dusty months have you experience in your locality in a year?_____months

5. Do you think air pollution has affected your/ your household members' daily activities?
(1) Yes (2) No

6. Do you avoid main roads during peak hours of traffic? (1) Yes (2) No

7. Do avoid exposure to dust have you taken a different route to your work/school/market?

(1) Yes (2) No

8. Do you use handkerchiefs, duppatta, eye goggles or any protective clothes when you travel though these roads? (1) Yes (2) No

9. Do you stay indoors to avoid such exposure, any loss of workdays due to this?

(1) Yes (2) No

10. What kind of averting measures do you use to avoid dust exposure?

Recall survey

Household Health Care

1) If you have a health problem where do you go for treatment and why?

   I. Private doctor ☐ Why?_____

   II. Health centre/ hospital ☐ Why?_____

   III. Homeopathy doctor ☐ Why?_____

   IV. Ayurvedic doctor ☐ Why?_____

   V. Others (specify) ☐ _____Why?_____

2) For which kind of illness do you visit a private doctor/ hospital and why?

_____

_____

3) For which kind of illness do you visit a government health centre/ hospital and why?

_____

_____

4) How do you rate the performance of the health care sector and why? (Refer to rating scale)

Sr. No	Sub Centre	PHC	CHC	Dist Hosp	GMC	Pvt. Doctor
Rating						
Reason						

5) Who is/are your family physicians/ doctors and where is/are the clinics located?
   i) Name:_____
   ii) Place:_____

Health diary format

Code _____

House No _____

Ward _____

Village _____

S.n	Member	Kind of ailment	Date	No of days sick	No of work lost	No of visits to doctor	Total medical expense	Additional comments

Annexure B

Contents

A Crop preferences through matrix ranking.....25

B Summary of discussion on costs and benefits.....27

C Metal estimation

Estimation of metal content in soil and biological samples in mg/kg 28

Estimation of bio-available metals in the soil system in mg/kg 31

A Community crop preferences through matrix ranking

The tables below shows the results of the matrix ranking exercise in each Cluster.

Table B-A.1 Matrix ranking exercise (Cluster I)

Benefit/ha	Cashew	Mango	Sapota	Jackfruit	Kokum	Tamarind	Aonla	Teak
Less labour requirement	3	5	5	5	3	3	5	5
Low water requirement	5	5	3	5	5	5	5	5
Higher financial return	5	3	2	4	4	3	5	5
Higher demand for local market	5	4	4	3	4	4	4	5
Higher demand for export market	5	4	1	1	3	2	1	3
Self consumption	5	5	4	4	4	3	2	5
Income tax benefit	1	1	1	1	1	1	1	1
Low occurrence of infestation(disease & pest)	4	4	2	5	5	3	3	5
Total	**33**	**31**	**22**	**28**	**29**	**21**	**26**	**34**

Table B-A.2 Matrix ranking exercise (Cluster II)

Benefit/ha	Cashew	Mango	Sapota	Jackfruit	Kokum	Tamarind	Aonla	Teak	Traditional Medicinal Plants
Less labour requirement	5	5	3	1	2	3	5	2	5
Low water requirement	4	3	1	5	5	5	5	5	5
Higher financial return	5	4	5	3	3	4	2	5	2
Higher demand for local market	5	5	5	2	5	3	3	5	3
Higher demand for export market	5	5	2	2	3	2	2	5	3
Self consumption	2	2	4	5	4	4	4	3	5
Income tax benefit	5	5	5	2	2	2	3	4	1
Low occurrence of infestation(disease & pest)	3	3	4	4	5	4	5	5	5
Growth on dump	5	4	2	2	4	4	5	4	3
Total	**39**	**36**	**31**	**26**	**33**	**31**	**34**	**38**	**32**

Annexure B

Table B-A.3 Matrix ranking exercise (Cluster III)

Benefit/ha	Cashew	Mango	Sapota	Jackfruit	Kokum	Tamarind	Aonla	Teak
Less labour requirement	3	5	3	4	4	5	5	3
Low water requirement	5	5	3	4	5	4	4	4
Higher financial return	5	3	2	3	4	3	5	2
Higher demand for local market	5	4	3	5	3	3	3	2
Higher demand for export market	4	3	1	3	2	1	1	1
Self consumption	5	5	3	5	5	3	4	2
Income tax benefit	5	4	1	1	1	1	1	1
Low occurrence of infestation(disease & pest)	3	3	3	4	4	4	4	4
Growth on Dump	4	4	1	3	4	4	4	3
Total	39	36	20	32	32	28	31	22

Annexure B

B Summary of discussion on costs and benefits

Table B-B.1 Summary of discussion on costs and benefits of vegetation during focus group meetings

Cost /ha	Cashew	Mango	Sapota	Jackfruit	Kokum	Tamarind	Amla	Teak
Pit digging (Rs./ pit)	10	15	8	15	10	15	10	10
Amendment & fertilizer (Rs.)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Manure per pit (Rs./ pit)	7	Nil	8	Nil	5	Nil	Nil	Nil
Labour cost for mixing and application (Rs per 50 pits)	150	150	150	150	150	150	150	150
Cost of sapling perseedling/graft	10	25	15	10	10	10	40	10
Cost of stakes (Rs Per stake)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Labour cost of planting and staking (Rs per 60 number)	150	150	150	150	150	150	150	150
Cost of irrigation (Rs per plant)	45	45	45	45	45	45	45	45
Weeding & Mulching (Rs/ plant)	18.75	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Pest control (in severe attack)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Benefit/ha	**Cashew**	**Mango**	**Sapota**	**Jackfruit**	**Kokum**	**Tamarind**	**Amla**	**Teak**
Produce								
1. Nuts (kg/ plant)		Nil	Nil	Nil	Nil	Nil	Nil	Nil
2. Fruits (per plant)	25 kg	499 nos	500 nos	25-40 nos	20-25 kg (dry kokum)	25 kg	25-30 kg	Nil
3. Fuel wood	depends on availability of deadwood	depends on availability of deadwood	depends on availability of deadwood	depends on availability of deadwood	depends on availability of deadwood	depends on availability of deadwood	depends on availability of deadwood	depends on availability of deadwood
4. Org. manure	for plant itself	for plant itself	for plant itself	for plant itself	for plant itself	for plant itself	for plant itself	for plant itself
5. Other (per plant)					5 kg seeds (dry)			Timber
Income tax								
Environmental benefit	shade	shade	shade	shade	shade	shade	shade	shade
Soil conservation	yes	yes	yes	yes	yes	yes	yes	yes
Water conservation	yes	yes	yes	yes	yes	yes	yes	yes
Environmental stability	yes	yes	yes	yes	yes	yes	yes	yes

C Metal estimation

Results

Total metal content in soil and biological samples for the five metals viz. Chromium (Cr), iron (Fe), Manganese (Mn), Nickel (Ni) and Zinc (Zn) is presented in the Table B-C.1 below.

(Codes are provided below the table.)

Table B-C.1 Estimation of metal content in soil and biological samples in **mg/kg**

S. No	Code name	Cr	Fe	Mn	Ni	Zn
1	I Aa	28.11666	4541.459	117.4833	96.15665	187.2966
2	I Ab	6.836667	3849.067	237.23	67.99333	183.7733
3	I Ac	401.8	252693	3824.753	143.5	532.8633
4	I Ad	7.384314	5645.596	335.7529	58.93725	138.7922
5	I Ba	13.20667	7081.06	396.27	13.06667	344.19
6	I Bb	89.22667	26006.26	901.32	114.1467	92.96
7	I Ca	6.93	1682.333	33.69333	111.2767	40.85667
8	I Cb	18.29333	5121.807	195.79	127.68	78.21333
9	I Cc	363.5333	156909.6	2229.033	223.86	500.3367
10	I Ga	19.36667	4343.407	109.6433	108.3133	105.5133
11	I Gb	39.508	5567.94	186.676	141.792	127.148
12	I Gc	339.808	279621.8	2428.02	4561.004	608.44
13	I Ha	31.668	801.696	106.904	151.704	88.648
14	I Hb	8.904	4279.38	599.396	134.4	207.508
15	I Hc	365.064	256000.6	2111.172	1395.968	622.216
16	II Aa	37.38	5050.052	104.776	106.988	191.52
17	II Ab	40.376	4684.4	771.96	148.792	151.144
18	II Ac	250.264	286663.6	26075.67	746.2	782.936
19	II Ad	7.082353	5032.885	123.1341	86.47059	177.4541
20	II Ba	23.66	60713.35	1541.428	143.108	129.388
21	II Bb	33.628	2464.252	500.78	149.1	180.012
22	II Bc	691.096	264596.8	4949.028	435.092	500.528
23	II Mb	13.272	1847.104	268.492	128.296	45.416
24	III Aa	61.656	2282.812	79.576	125.804	131.684
25	III Ab	22.12	4984.336	606.62	105.672	104.916
26	III Ac	2325.848	234520.3	115878	5227.992	6262.34
27	III Ad	65.66	4328.296	3542.644	151.788	185.5
28	III Ad	381.4259	5192.551	192.4753	231.7412	275.5859
29	III Fc	76.916	3778447	7481.516	6447.168	2428.02
30	III J	131.488	4344.48	125.804	157.08	110.964
31	III Kb	8.148	21038.64	563.108	145.152	44.968
32	III Kc	187.124	302560	274.372	910.364	394.912

Contd.

Table B-C.1 *Contd.*

33	III Mc	561.372	301389	1404.004	2059.512	383.432
34	III Nb	9.648	16317.5	1186.872	12.336	76.752
35	III Nc	495.936	297631.6	7114.156	1165.22	658.952
36	IV Aa	7	5623.688	213.276	30.604	40.18
37	IV Ad	5.796	4682.636	113.12	185.024	40.04
38	IV Ab	8.148	3806.208	509.068	47.096	53.592
39	IV Ac	375.396	252496.9	5085.64	2570.372	546.448
40	IV Ad	0.428235	809.1012	61.79765	111.2753	105.3459
41	IV Ba	4.228	3730.552	236.124	107.156	56.028
42	IV Ba	7.952	3594.108	830.088	94.192	157.976
43	IV Bc	233.044	311870.3	3283.28	1455.664	456.904
44	IV Ca	1.512	1015.728	35.896	62.692	54.348
45	IV Cb	5.516	2742.404	156.632	56.14	71.176
46	IV Cc	640.584	281674.4	1172.108	482.16	570.556
47	IV Ea	1.064	2129.26	538.552	177.632	57.036
48	IV Eb	6.916	3191.468	5683.664	86.94	93.856
49	IV Ec	179.088	65656.42	15957.2	1561.28	3649.492
50	IV Fa	5.712	23929.25	861.868	47.964	209.16
51	V Aa	5.064	3229.248	78.96	31.8	199.416
52	V Ab	5.88	2525.136	60.984	25.248	158.208
53	V Ac	414.264	215785.3	7280.616	1317.576	665.184
54	V Ad	1.327059	4049.082	396.8753	81.57176	445.4965
55	V Ba	6.24	2744.616	96.408	114.696	198.816
56	V Bb	10.608	33034.68	3915.84	16.344	228.264
57	V Bc	465.432	206934.2	5803.632	967.272	844.272
58	V Cb	3.048	4993.368	877.056	60.072	160.68
59	V Cc	309.96	249478.4	8495.856	948.576	986.952
60	VI Aa	5.684	728.28	47.964	65.744	213.696
61	VI Ab	8.76	5249.304	759.864	58.248	221.832
62	VI Ac	380.808	261000.1	2133.312	541.2	824.592
63	VI Ad	31.65176	6338.654	241.9765	72.11294	244.4329
64	VI Ba	97.8	5497.056	178.944	61.992	121.368
65	VI Bb	24.24	5783.04	3274.848	59.712	125.88
66	VI Bc	314.88	267160.9	3272.784	982.032	556.944
67	VII Aa	0.144	1464.312	36.984	60.888	196.2
68	VII Ad	10.73254	60563.18	1064.003	58.21124	170.8773
69	VII Ab	4.536	4544.568	762.168	70.08	233.4
70	VII Ad	4.884706	7013.421	228.5647	71.94353	349.9765
71	VII Bb	4.824	4612.152	7579.44	68.76	191.688
72	VII Bc	314.88	239410.2	8987.856	187.8456	848.208

Contd.

Table B-C.1 *Contd.*

73	VIII Aa	18.576	1135.656	17.784	5.184	115.224
74	VIII Ac	362.112	19807.92	1128.648	615.984	472.32
75	VIIIAd	19.584	3904.248	144.648	10.2	182.568
76	VIII Ba	20.616	1677.456	56.928	11.544	108.624
77	VIII Bb	32.352	16142.11	405.048	14.736	125.736
78	VIII Bc	353.256	20076.55	519.552	3430.224	561.864
79	VIII Cb	52.8	5360.664	194.832	12.624	170.184
80	IX Aa	23.376	2167.08	46.992	7.32	123.072
81	IX Ab	29.304	5209.32	361.08	8.52	175.104
82	IX Ac	218.448	9215.16	989.904	3244.248	606.144
83	IX Ad	28.12235	5738.174	100.9694	20.32941	219.3318
84	IX Ba	33.024	1712.208	72.192	13.08	153.744
85	IX Bb	27.408	4923.264	772.584	14.328	176.16
86	IX Bc	379.824	17442.38	443.784	2862.456	457.56
87	IX Cb	27.36	4015.68	142.08	5.952	114.168
88	IX Cc	1630.488	152407.8	2283.864	461.496	929.88
89	IX Ha	19.92	1688.136	81.648	6.36	154.2
90	IX Hb	4.944	3605.808	51.12	22.848	9.432
91	IX Hc	6294.648	4363999	73242.07	3628.008	6542.616

I – IX are stations for sample collection; A-N are plants and a-d are the parts of the plants.
A- Cashew, B- Mango, C-Sapota, D-Chicku, E- Banana, F- Pineapple, G-Tamarind, H-Jackfruit, I- Paddy, J-grass, K-Amla, L-Tomato, M- Acasia, N-Casuarina
a-Fruit, b-Leaves, c-Soil, d- Nuts

Biologically available metals (Chromium (Cr), iron (Fe), Manganese (Mn), Nickel (Ni) and Zinc (Zn)) in the soil system as estimated using DTPA extraction procedure is given in Table B-C.2, below. (Codes are provided below the table.)

Table B-C.2 Estimation of bio-available metals in the soil system in mg/kg

S. No.	Code	Cr	Cu	Fe	Mn	Ni	Zn
1	I Ac	59.25	13.37	202.79	432.88	31.00	37.60
2	I Cc	40.55	10.62	194.01	94.83	3.90	34.24
3	I Gc	21.65	10.21	111.36	169.21	29.81	30.09
4	I Hc	16.89	5.86	48.79	357.56	15.58	22.22
5	II Ac	36.57	13.00	139.65	462.07	52.97	29.64
6	II Bc	20.83	6.64	40.22	47.07	61.21	21.77
7	III Ac	22.14	5.04	56.91	182.74	16.61	16.65
8	III Fc	17.22	6.15	57.20	224.97	23.12	6.27
9	III Kc	16.77	7.87	41.41	40.92	4.18	15.91
10	III Mc	25.83	6.56	63.18	70.60	44.98	7.09
11	III Nc	29.44	5.66	61.05	25.17	53.92	5.66
12	IV Ac	33.01	10.87	143.05	917.01	38.99	16.52
13	IV Bc	12.34	14.51	187.41	520.86	34.19	17.30
14	IV Cc	12.59	30.91	157.89	327.96	22.51	47.81
15	IV Ec	13.90	13.33	87.17	238.09	72.94	20.66
16	V Ac	15.83	16.85	153.55	714.34	27.47	13.24
17	V Bc	66.58	14.97	84.99	360.51	34.44	21.77
18	V Cc	48.38	6.77	59.74	203.85	39.32	7.09
19	VI Ac	18.78	7.67	84.01	85.03	51.00	7.75
20	VI Bc	20.21	15.13	50.06	145.76	55.39	7.38
21	VII Bc	42.11	6.60	43.87	147.52	18.74	5.04
22	VIII Ac	17.84	25.83	635.66	316.56	68.84	46.21
23	VIII Bc	24.76	15.58	127.14	179.13	1.23	12.75
24	IX Ac	30.83	13.12	354.81	156.37	59.08	11.07
25	IX Bc	52.77	13.04	426.56	434.40	69.17	25.05
26	IX Cc	19.02	18.16	100.12	135.51	9.31	26.57
27	IX Hc	12.38	21.16	183.07	404.01	24.72	18.61

I – IX are stations for sample collection; A-N are plants.
A- Cashew, B- Mango, C-Sapota, D-Chicku, E- Banana, F- Pineapple, G-Tamarind, H-Jackfruit, I- Paddy, J-grass, K-Amla, L-Tomato, M- Acasia, N-Casuarina, c-soil

Annexure C

Contents

A Governance in the context of air quality in mining areas 33

B Governance case study: Responses to changes in ground water and shortages of water for household use 47

C Health data management case study..... 66

D Format for communicable diseases..... 73

E Format for non-communicable diseases (general morbidity) data..... 74

F Governance questionnaire..... 75

A Governance in the context of air quality in mining areas

One of the main impacts of mining on air quality is high particulate matter levels, often exceeding the standards laid down by the Central Pollution Control Board (CPCB). (This has been discussed in detail in Chapter 2).

This problem is caused by the overloading of trucks carrying ore from the mine site to barges waiting along the river. Over loaded trucks that are inadequately covered speed down poor roads leading to the spillage of ore. Continuous movement of trucks along road corridors leads to re-suspension of dust and high particulate matter levels. As trucks are generally plying through densely populated areas, air pollution generated has an adverse impact on community health. Mining companies and truck operators have a key role to play in preventing this problem. Companies and truck operators need to ensure that trucks being loaded within the mine site are not overloaded and they are properly covered. While these steps are very easy to follow, both companies and truck operators are unwilling to follow them. There is also a well-developed regulatory framework that empowers various agents to take action. However, this also seems to be ineffective in controlling the problem.

In order to understand how and why the problem of air pollution persists this component presents a brief overview of the legislative framework that deals with air pollution management and goes on to explore:

- Political-economy of trucking
- The community's role in responding to air quality problems

Overview of the legislative framework

Agent	Empowering legislation	Regulatory role	Reasons offered for lack of enforcement of laws
Indian Bureau of Mines (IBM) and Department of Mines (DoM)	MMRDA 1957 MCR 1960 MCDR 1967	• Regulate mining activities within the lease areas according to mining plan • Ensure environmental standards are met • Jurisdiction extends to lease area and buffer zone	• The air pollution problem is outside the lease area. • Caused by trucking and not mining.
Goa State Pollution Control Board (GSPCB)	Air (Pollution Prevention and Control Act) 1981	• Regulate industries that are polluting • Monitor air pollution • Enforce air pollution standards • Jurisdiction includes the whole state of Goa	• Mining is not an industry- it is a primary sector activity. • Cause of the problem is within the lease area which is not within their jurisdiction • Cannot monitor air quality because of lack of staff and equipment
Road Transport Office (RTO)	Motor Vehicles Act 1988	• Ensure road safety rules and regulations are followed, including loading of trucks within permissible limits • Monitor and enforce fuel emissions standards	• No weigh bridges to check overloading • Understaffed • Over loading of trucks should be monitored at the time of loading which is inside the lease area
Panchayats	Goa *Panchayati Raj* Act 1998	• Monitor and regulate emissions of smoke from commercial furnaces	-

Economics of trucking

Over the years, the transportation of ore by trucks has been almost completely outsourced by mining companies. Outsourcing of the business of transporting ore has had led to several changes:

- New income opportunities have been generated and local residents have developed a stake in the industry
- Mining companies have been relieved of the liabilities associated with owning, running and maintaining a fleet of trucks
- Regulation of trucking has become more difficult. From being an activity carried out by a dozen companies, transportation is now done by several thousand truck owners from the local communities.
- Outsourcing has allowed the Indian Bureau of Mines (the agent responsible for regulating all activities related to mining) to distance itself from this problem because it is technically not caused by mining companies but by truck owners. Simultaneously, the State Pollution Control Board and the Regional Transport Office are now more involved in regulation.

There are over 9000 trucks working directly with mining companies to move ore within the mine as well as transport it outside the mine to jetties where it is unloaded into barges. Most of the trucks operating in the region have been bought with the help of loans taken from local banks[1]. The terms and conditions for loans stipulated by most banks are similar, with slight differences regarding paper-work or guarantors needed etc. An outline of terms and conditions are presented below:

- Loans offered for 80-85% of the cost of a truck with a down payment of 20-15% of the cost
- A collateral of Rs. 1 lakh as a fixed deposit (waived if the bank is familiar with the individual taking the loan)
- Guarantors (1 or 2 depending on the bank)
- Interest rates vary between 11.75% - 15% per annum
- The loan has to be paid off between 5-7 years while the individual is exempt from making monthly payments to the bank during the monsoon season when mining activities are suspended and transportation of ore is not undertaken

[1] An alternative but less common arrangement to get a loan for a truck is through a mining company. The mining company purchases the truck and gives it to an individual interested in purchasing a truck. The mining company deducts monthly payments towards the truck from the earnings of the individual till the loan is paid off.

Table C-A.1 shows how the profitability of the business as calculated by banks providing loans. This estimate is based on a 20 km transport route[2].

Table C-A.1 Estimates of Costs and Revenue for a long route

REVENUE		COSTS*	
Head	**Rs.**	**Head**	**Rs.**
Transportation rate (Rs/tonne)	30	Per litre Average (Km/L)	3.5
Average run per trip (kms)	20	Average run per trip (kms)	20
Load per trip (tonnes)	14	Total Km run/month	5000
No. of trips/day	10	Total fuel consumption/month (Litres)	1429
Average no. of days working/month	25	Cost of Fuel (Rs./Litre)	30
Total tonnage transported/month	3500	Total spent on fuel + oil	44,857.14
Revenue/trip	420	Taxes/month	800
Revenue/day	4200	Insurance/month	2,000
REVENUE - Rate Rs./Tonne/Km	1.50	EMI	16,430
		Margin money spread over the term of the loan	2,449
		Salary to Driver & Cleaner	8,000
		Repairs & Replacement	10,500
		Living Expenses	3,000
Total Revenue/Month	**105,000.00**	**Total Costs/Month**	**88,035.71**

Table C-A.1, above shows that truck owners can make a healthy profit of Rs. 16, 964 per month, that is a profitability of about 19% (on costs) using the above calculation. The table also shows, however, that banks calculate this level of profitability using 14 tonnes as the load per trip which exceeds the 10 ton limit3. This is highly problematic because overloading of trucks is one of the main causes of air pollution in the region.

While the law permits carriage of 10 tonnes, the economics at 10 tonnes do not present favourable terms of business and truck owners run into losses. Table C-A.2 (below) presents marginal costs and revenues for the transport of ore. Based on these calculation we see that at ten tonnes the profitability would be negative with the truck owner making a loss of about Rs. 13,035 (-14.8%) every month. We see that for every tonne of ore carried in excess of ten tonnes, the marginal cost of transportation decreases, while the marginal remains constant. Only if a truck owner carried 12 tonnes would he break even. Hence, as long as the economics are such, truck owners have no incentive to abide the law. Figure C-A.1 graphically represents the data in the tables, showing the point at which profits become positive and the business is viable.

[2] Transportation rates are calculated based on the distance covered by trucks and is paid per tonne of ore carried. Rates therefore vary depending on the mining company and the distance to be covered. While we have presented only one example, we conducted several such calculations based on rates from different banks, truck operators and members of a truck owners association. All used more than 10 tonnes for their calculations.

[3] All goods carriers, have a "rated capacity" that is determined by the manufacturers. This sets the limit of the load the vehicle can safely carry. According to the Motor Vehicles Act (1988) plying of vehicles that are loaded beyond their rated capacity is a punishable offence and liable to a penalty.

Table C-A.2 Marginal costs and revenues for transportation of ore

Tonnes carried	Marginal revenue (Rs./tonne/km)	Marginal cost (Rs./tonne/km)	Profit (Rs./tonne/km)	Profit (Rs./month)
10	1.50	1.76	-0.26	-13,035.71
11	1.50	1.60	-0.10	-5,535.71
12	1.50	1.47	0.03	1,964.29
13	1.50	1.35	0.15	9,464.29
14	**1.50**	**1.26**	**0.24**	**16,964.29**
15	1.50	1.17	0.33	24,464.29

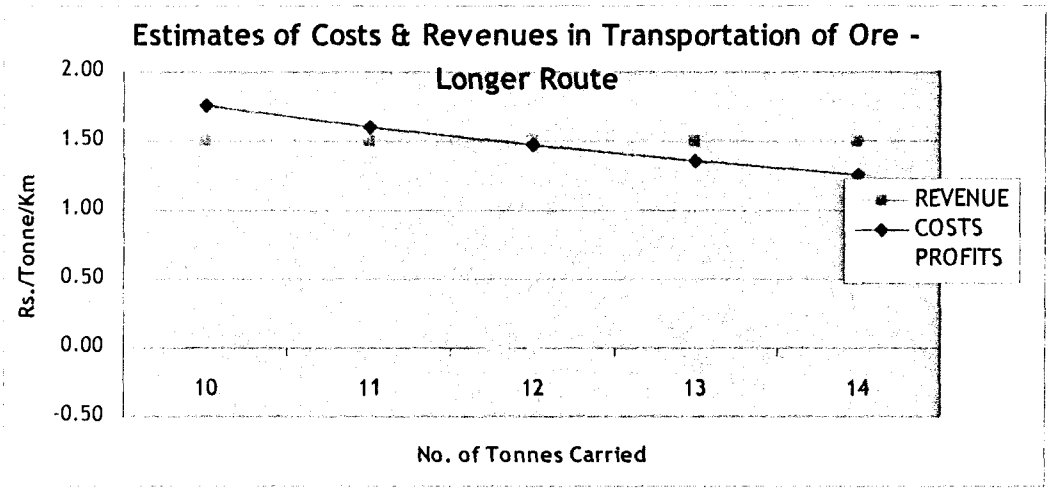

Figure C-A.1 Estimates of costs and revenues in transportation of ore

We explore further, what options exist for truck operators in order to stay within the ten-tonne limit and continue making profits at the current rate. Truck operators can either decrease costs or increase revenues. Through analysis we find that most of the components of the cost are unchangeable by truck owners, eg. taxes, insurance, interest on the loan, fuel prices, depreciation, maintenance etc.) The only elements of cost that truck operators can alter are the salaries of the drivers and cleaners, where they would be able to make marginal savings.

On the revenue side, they could increase the number of trips they make a day. However, if the tonnage carried were decreased to 10 then each truck would have to nearly double the number of trips to generate the current levels of revenue. This would not be possible on two accounts; firstly there are too many trucks in the business for each one to get twice the amount of work they currently do[4]; and secondly, in terms of the time available in a day, it is an impossibility.

[4] Interviews with truck owners reveal that in certain sectors, due to increasing competition, drivers can do no more than 4 trips a day when they used to do between 10-14 trips a day in the past!

For trucks to stay within the loading limit, the only option then is to increase the revenue they earn per trip by revisiting the rate paid for transportation. We assume that truck owners are happy with a business as usual scenario, whereby the profits they currently earn (24 paise/tonne/km or a total profits of Rs. 16,964/month) are sufficient for them to continue to operate. If now we reduce the tonnage carried from 14 to 10 tonnes, the transportation rate would have to go up to Rs. 2.10/tonne/km for truck owners to earn the same net profits.

Yet, increasing the rate of transportation is not something truck owners can do unilaterally. They are price takers in a competitive market. Transportation rates are negotiated with each company and settled once every financial year. Unless there is a very sharp change in factor prices, rates are nearly unchangeable. Sometimes truck owner strike work, but these strikes are not very effective because leaders are either bought out, or if a strike drags on for too long, truck owners do not have the staying capacity; they need the work in order to pay back the loans and slowly the strike fails.

In general truck owners we spoke with said that they have very little influence over the rates of transportation; it is the companies who do. Increasing transportation rates increases costs for mining companies and is therefore not in their business interest. While companies may agree to a marginal increase in rates, a 35% - 40% increases would be very difficult if not impossible to get. The easiest adjustment available to the truck owners therefore, is to overload their trucks so as to earn more revenue per trip. Mining companies also prefer this solution since it has a direct bearing on their costs, thus companies overlook overloading of trucks by operators.

Mining companies and government representatives claim that truck owners have unreasonable expectations from the transportation business and even if transportation rates were raised, they would continue to overload since it would mean still more earnings for them. Speaking to truck owners we realise that earlier, when there were fewer trucks, the profit margins were higher. They say that profits were up to 3 times the amount they spent on variable costs like fuel. Now they say the returns have fallen drastically as there is intense competition, and they feel it will only decrease with time. Expectations play a big role in the perception of the profitability of the business. By comparing current profits to those earned before, the perception that the business is not profitable creates the push to earn more. Since overloading is the easy way to do so, truck owners may well break the law even if rates were to increase, unless they are deterred by a heavy fine.

Role of the fine

According to the Motor Vehicles Act (1988) if a vehicle is caught carrying weight in excess of the permissible limit, it is charged a fine of Rs. 2000 plus Rs. 1000 for every tonne in excess of the limit. Therefore, if a truck is carrying 12 tonnes it will have to pay a fine of Rs. 3000, or a fine of Rs. 4000 if it is caught carrying 13 tonnes. Under this penalty structure, if a truck owner must overload, he will choose to overload by more than 2 tonnes (see Table C-A.3 below). If a truck is caught with 12 tonnes, the fine is Rs. 3000 while his monthly net profit at that level of tonnage is about Rs. 1200. If he loads 13 tonnes and is caught once that month (the frequency with which the weight of trucks is checked is very low), then even after paying

the fine, his net profits are more than Rs. 4000 for that month. We see that if the enforcement of the law is weak, then in this case the penalty structure is such that it provides an incentive to violate the law with greater impunity.

Table C-A.3 Profits under the current fine structure (Rs/month)

Tonnes carried	Monthly profits under current rates	Monthly profits under revised rates	Fines
10	-13,035.71	**16,964.29**	0.00
11	-5,535.71	24,967.53	2000
12	1,964.29	31,636.90	3000
13	9,464.29	37,280.22	4000
14	**16,964.29**	42,117.35	5000
15	24,464.29	46,309.52	6000

Further, if transportation rates were raised and the fine structure not revisited, truck operators could continue to load at levels they have been doing, factor penalties into their costs and still earn high profits. Thus, while raising transportation rates it is important to also revisit the penalty structure.

Conclusion

This study highlights the vested interests of each party in maintaining the status quo. Given the current power dynamics, truck operators are unable to force companies to raise rates. Thus, they are left with no choice but to overload. Financial institutions are also profiting from this situation while they support truck operators to break the law. Meanwhile companies save money by keeping transportation rates low and turning a blind eye to overloading. There are also examples of people in positions of power that have vested interests blocking solutions to the air quality problem[5].

In the study area it is common knowledge that in the mining areas RTO/police officers are bribed to ensure that overloaded trucks are not penalised. While it is very difficult to get any hard facts and figures on who is paid, how much and how and till what level the bribe money collected travels up the official ladder, it is common knowledge that bribes are paid and asked for.

Both truck owner's associations and companies are strong lobby groups and together wield significant power. They are able to use this power to prevent various state agents from enforcing the law. Other powerful agents benefiting from the transportation business also influence decision-making and enforcement of the law and prevent the problem from being addressed. Thus, despite an extensive regulatory framework, air pollution continues to persist.

[5] A state-of-the-art iron ore handling terminal that has been suggested as an alternative to truck transportation has not yet received the green signal after being proposed almost 5 years ago. This project met with roadblocks as the local Member of the Legislative Assembly (MLA) has high stakes in the transportation business and will lose a significant portion of his business if the status quo is disturbed. In this manner, vested interests of people in power block solutions to the problem.

Role of civil society

Broadly speaking, with the authority to enforce regulations have done little to implement the law regarding air pollution. The role of civil society becomes extremely crucial when government fails to respond to persisting issues. Yet, in the mining areas the role of civil society is constrained by the fact that livelihood opportunities are limited and there is dependence and expectations from mining and allied activities for employment. Through the governance survey carried out in the study area we attempted to study the following:

- what factors that influence civic activity and willingness to protest, specifically dependence on mining/trucking for work and age of mining
- who does the local community approach to address their problem of poor air quality and how do they perceive these agents.

The results from the survey are presented in the tables below.

Table C-A.4 Reporting of air quality problems

Cluster	Count/Percentage	Yes	No	Total
I	Count	42	27	69
	% within cluster	60.90%	39.10%	100.00%
II	Count	134	26	160
	% within cluster	83.80%	16.30%	100.00%
III	Count	154	54	208
	% within cluster	74.00%	26.00%	100.00%
Total	Count	330	107	437
	% within cluster	75.50%	24.50%	100.00%

Table C-A.4 (above) shows the cluster-wise distribution of responses to the question whether respondents felt they had a dust problem in their wards. Nearly 3 out of every 4 people in the entire study area reported that dust pollution was a problem. From those living in Cluster II, almost 84% reported to have a dust related problem, which was the highest from among the three clusters, with clusters III and I coming in second and third place respectively. (Cluster II being most stressed in terms of air pollution also emerges through environmental monitoring conducted in this study.)

Table C-A.5 Who complained about air quality?

Complaining behaviour by cluster				
Cluster	Count/Percentage	No	Yes	Total
I	Count	14	28	42
	% within cluster	33.30%	66.70%	100.00%
II	Count	62	70	132
	% within cluster	47.00%	53.00%	100.00%
III	Count	72	80	152
	% within cluster	47.40%	52.60%	100.00%
Total	Count	148	178	326
	% within cluster	45.40%	54.60%	100.00%

The table above looks at complaining behaviour of those respondents who reported having air quality problems to understand whether people actively take up the issue with different agents. Overall around 55% of those reporting air quality problems complained about it. From those who reported having air quality problems the largest proportion complaining was found in Cluster I. Clusters II and III have about the same proportions complaining regarding this matter.

One of the hypotheses we wanted to test was that complaining regarding poor air quality is influenced by the fact that an individual/family may be dependent on mining or allied occupations. We would expect that those involved in mining or allied occupations (truck transport, garages, working on barges etc...) will be less likely to complain about the poor air quality, since doing so is perceived to threaten their livelihood.

Influence of occupation on complaining behaviour

The table below shows the subset of people who reported having poor air quality. For those respondents who were dependent on mining or allied occupations we see that nearly as many reported complaining about the dust problem as did not. For those respondents on who were not dependent on mining or allied jobs, a greater proportion (57.5%) reported having had complained about the problem than not. There is no statistically significant difference in the complaining behaviour (Chi-square = 1.618; df = 1; P-value = 0.203) of those with and without mining jobs, but those without mining jobs are 1.62 times likely to complain as opposed to those who have mining or allied jobs.

Table C-A.6 Kind of occupation and complaining behaviour

Mine related work	Count/Percentage	No	Yes	Total
No	Count	82	111	193
	% within mine related work	42.50%	57.50%	100.00%
Yes	Count	66	67	133
	% within mine related work	49.60%	50.40%	100.00%
Total	Count	148	178	326
	% within mine related work	45.40%	54.60%	100.00%

Table C-A.7 Kind of occupation and complaining behaviour - Cluster-wise

Cluster	Occupation	No/yes	Count/Percentage	No	Yes	Total
I	Mine related work	No	Count	9	25	34
			% within mine related work	26.50%	73.50%	100.00%
		Yes	Count	5	3	8
			% within mine related work	62.50%	37.50%	100.00%
	Total		Count	14	28	42
			% within mine related work	33.30%	66.70%	100.00%
II	Mine related work	No	Count	35	35	70
			% within mine related work	50.00%	50.00%	100.00%
		Yes	Count	27	35	62
			% within mine related work	43.50%	56.50%	100.00%
	Total		Count	62	70	132
			% within mine related work	47.00%	53.00%	100.00%
III	Mine related work	No	Count	38	51	89
			% within mine related work	42.70%	57.30%	100.00%
		Yes	Count	34	29	63
			% within mine related work	54.00%	46.00%	100.00%
	Total		Count	72	80	152
			% within mine related work	47.40%	52.60%	100.00%

Data from the previous table has been analysed (above) cluster-wise to see whether there are any patterns emerging within clusters regarding active protests against the dust pollution problem. In Clusters I and III we see that a greater fraction of the respondents without mining or allied jobs complained about the dust problem than with such jobs. Interestingly in Cluster II, we see the opposite where a greater proportion of respondents with mining or allied jobs complained about the dust problem than without. One possible explanation for this could be that since air quality conditions in Cluster II seem to be worse than those in the other two clusters and that the road corridor passes through thickly populated areas, the impact on people in general is high and this prompts people to actively respond to the dust problem, irrespective of whether they do or do not have mining or trucking jobs.

Through the survey we were also able to see the level of political activity (measured as active protest against an issue) of the people residing in the three clusters. Based on the age of mining theory (which claims that increasing years of mining activity in an area positively influence determinants of political activity like income, education, awareness etc...), we expect that with increasing age of mining, the level of political activity increases. In Table C-A.8 we find that the average complaints made per household is highest in Cluster I followed by Clusters II and III.

Level of political activity across clusters

Table C-A.8 Complaints regarding air quality

Cluster	No. of people having air quality problems	No. of people complaining	No. of complaints made	Average complaints/ person	Percentage of those having problems, actively complaining
I	43	28	57	2.04	65.12
II	133	70	85	1.21	52.63
III	154	79	92	1.16	51.30
Total	**330**	**177**	**234**	**1.32**	**53.64**

Other indicators of level of political activity and participation around solving the problem of dust can be found in the following tables where we see how often the dust problem is discussed at the Gram Sabha meetings and to what extent have people participated in protest marches (or morchas/dharnas)

Table C-A.9 Discussing air quality issues at the *Gram Sabha*

Cluster	Regularly/ sometimes	Rarely/ never	Don't know	Total
I	50.00%	22.20%	27.80%	18
II	38.90%	33.30%	27.80%	72
III	32.30%	21.50%	46.20%	65
Total	**37.40%**	**27.10%**	**35.50%**	**155**

The table above tells us how often air quality issues are discussed in the Gram Sabhas of those panchayats where dust problems have been reported to exist. The responses are taken only from those respondents who claimed to attend Gram Sabha meeting regularly/sometimes. Most respondents from Cluster I (50%) said that air quality issues are discussed regularly/sometimes at the Gram Sabha meetings, followed by Cluster II (38.9%) and then Cluster III (32.3%).

The table below tells us what proportion of respondents participate in protests pertaining to the dust problems experienced in the different clusters. We see that the highest participation is in Cluster I (27.5%), followed by Cluster III (20.8%) and then Cluster II (5.5%).

Table C-A.10 Participation in *morchas* regarding air quality problems

Cluster	Count/Percentage	Participation			
		Yes	*No*	*Don't Know*	*Total*
I	Count	11	28	1	40
	% within cluster	27.50%	70.00%	2.50%	100.00%
II	Count	7	116	5	128
	% within cluster	5.50%	90.60%	3.90%	100.00%
III	Count	30	101	13	144
	% within cluster	20.80%	70.10%	9.00%	100.00%
Total	Count	48	245	19	312
	% within cluster	15.40%	78.50%	6.10%	100.00%

We can conclude that in terms of levels of political activity, we observe that Cluster I is more active than Cluster II which is more active than Cluster III with regards to the level and intensity of complaints and discussion of the issue at the Gram Sabha. As far as protest marches go, Cluster I is still more active, but Cluster III has had more protest marches than Cluster II.

While an active and alert civil society can play the role of a watchdog and influence the enforcement of existing rules, civil society action is seen to be weak or ineffective in the mining areas for a number of reasons. Interviews with community members, village leader etc. reveal that residents who complain about the dust problems are often made stakeholders in the industry by offering them transportation sub-contracts or jobs in the mines. An example of this can be seen in South Goa where in one of the wards severely affected by dust, a popular movement was successfully quashed by sub-contracting the loading and unloading of iron ore to families/houses in the ward. As a result, the opposition to the activity effectively ceased. Ironically, in the mining areas, protest has become a common way to get a job or get money from companies or contractors. In the few cases we came across where members of the community have attempted to take up the issue, they have complained of being harassed and even intimidated by powerful lobby groups.

We now take a look who the community turns to with its problem of dust pollution. Table C-A.11 shows the agents/agencies that respondents approached to register complaints about the dust pollution problems they face.

Table C-A.11 Who do people complain to regarding air quality? **(percentages)**

			All other agents						
Cluster	*Panchayat*	Mining company	*Gram Kruti Samiti /other village groups*	*MLA*	*Member of parliament*	*Mamlatdar*	*Collector*	*Other*	*Total other agents*
I	31.58	33.33	0	3.51	7.02	12.28	5.26	7.02	35.09
II	38.82	52.94	1.18	1.18	2.35	3.53	0	0	8.24
III	68.48	17.39	1.09	4.35	0	2.17	1.09	5.43	14.13
Total study area	**48.72**	**34.19**	**0.85**	**2.99**	**2.56**	**5.13**	**1.71**	**3.85**	**17.09**

The table above shows that the Panchayats and the mining companies are the two most commonly approached agents regarding air quality problems. In the whole study area looked at together, the panchayat is most likely to be approached, with mining companies as the next option. Looking at this cluster-wise, we see that in Cluster I nearly equal proportions approach the panchayats (31.58%) and mining companies (33.33%) regarding air quality issues. Additionally looking at all other agents together (the last column), we see that almost an equal fraction of those complaining, go to various other agents (35%). This is the highest among the three clusters. In Cluster II, a greater fraction of the complaints are made to mining companies (nearly 53%) than to panchayats (nearly 39%) and only about 8% of the complaints are made to various other agents. In Cluster III clearly the largest fraction of

complaints are made to the panchayat (68.4%), followed by the mining companies (17%) and about 14% of the complaints are made to various other agents.

To further understand who people choose to approach regarding the dust problem we looked at those people who had approached only one agent (137 out of 178 who took some action to address their air quality problems), and wanted to know which agent was chosen. The first choice for those complaining once differs across clusters. Cluster I had as many respondents approach both the panchayat and the mining companies, while in Cluster II, the mining companies were the first port of call. For Cluster III on the other hand, the panchayat was the most approached agent (Table C-A.12).

Table C-A.12 Who people complain to if they do it only once

Cluster	*Panchayat*	Mining company	MLA	Member of parliament	Other	N
I	46.15	46.15	0.00	0.00	7.69	13
II	36.36	60.00	0.00	1.82	1.82	55
III	78.26	13.04	2.90	0.00	5.80	69
Total	**58.39**	**35.04**	**1.46**	**0.73**	**4.38**	**137**

Cluster III seems to approach the Panchayat more than Clusters I and II regarding the air pollution problem. Since the Panchayat is the first port of call in a rural context people are likely to approach it first. It is possible however, that over time and through experience, the local community learns to deal directly with the mining companies as well as higher authorities in the government and we see that in Clusters I and II smaller fractions of people approach the Panchayat and more of them deal either directly with the companies or with other government agents.

Some of the conclusions that can be drawn from the data above is:

- This survey data suggests that with respect to air quality respondents are more likely to actively protest if they do not have mining/allied jobs.
- It is possible that the age of mining has influenced political activity and civic engagement, with areas where mining is oldest being most active vis-à-vis the relatively younger areas.
- Panchayats and mining companies the most approached agents
- In the older clusters (namely I and II) greater proportions of respondents go to agents other than the panchayat.

We now look at how the respondents perceived the two main agents, the panchayat and the mining companies with respect to the level of concern they showed regarding the dust problem as well as how effective these agents have been in addressing the problem.

Table C-A.13 Perception of attitudes of various agents towards the dust problem

Cluster	*Panchayats*			Mining companies			Others		
	1	*2*	*N*	*1*	*2*	*N*	*1*	*2*	*N*
I	33.30	66.70	18	52.60	47.40	19	64.70	35.30	17
II	0.281	71.90	32	31.80	68.20	44		100.00	7
III	15.00	85.00	60	21.40	78.60	14	33.30	66.70	12
Total	**21.80**	**78.20**	**110**	**35.10**	**64.90**	**77**	**41.70**	**58.30**	**36**

1 - Poor attitude/ showed no concern (%)
2 - Good attitude/ showed some or a lot of concern (%)

In the table above we focus on the two main agents who are approached by respondents regarding dust problems, i.e. the Panchayats and the mining companies. All other agents have been clubbed together under the heading "other" since the numbers going to any one other agent was not very large.

In the study area we see that a greater proportion of respondents felt that the panchayat showed concern regarding the dust pollution problem as compared to mining companies. As far as the attitude of the panchayats goes, the highest proportion of respondents from Cluster III (85%) felt that the panchayat showed concern regarding the dust issues followed by Cluster II (71.9%) followed by Cluster I (66.7%). As far as the mining companies go, again the proportion of respondents feeling that the mining companies showed concern was the highest in Cluster III (78.6%) followed by Cluster II (68%) and Cluster I (47.4%).

The table below captures how effective the respondents felt the agents were in actually addressing the problem of dust.

Table C-A.14 Effectiveness of various agents in handling the dust problem as perceived by respondents

Cluster	*Panchayats*			Mining companies			Others		
	Not effective %	*Effective* %	*N*	*Not effective* %	*Effective* %	*N*	*Not effective* %	*Effective* %	*N*
I	55.60	44.40	18	57.90	42.10	19	94.70	5.30	19
II	60.60	39.40	33	45.50	54.50	44	71.40	28.60	7
III	43.50	56.50	62	57.10	42.90	14	69.20	30.80	13
Total	**50.40**	**49.60**	**113**	**50.60**	**49.40**	**77**	**82.10**	**17.90**	**39**

We see that in Cluster I nearly an equal proportion of respondents felt that panchayats and mining companies were effective in addressing dust problem. In Cluster III a greater proportion of people felt that the panchayat (56.5%) was effective in addressing the dust issue as compared with the mining companies (42.9%). In Cluster II on the other hand, a greater proportion of respondents felt that the mining companies (54.5%) were effective in addressing dust problems as opposed to the panchayats (39.4%).

While Panchayats have little or no role to play in the regulation of air quality, they are approached by 31%, 38% and 68% of the people in clusters I, II and III respectively.

From the data presented above, we can conclude that:

- People have faith in their Panchayats and trust that their representatives will take their complaint forward to the relevant authority.
- People expect the panchayat top do something about the problem (between 92% - 95% of the respondents in a separate question said that they expected the panchayat to do something to solve the issue)
- Despite not having any significant legal authority to address the problem, between 39-56.5% of the respondents across the clusters felt that the panchayat was effective in addressing the problem

Conclusions

In the case of air pollution in mining areas of Goa, we see that there is extensive legislation to address the problem, but the enforcement of the law is weak. In the past the GSPCB has shirked its responsibility to 'prevent, control and abate' air pollution claiming that mining areas were not under its jurisdiction. Additionally, the GSPCB, the IBM and the RTO have passed the buck of responsibility from one to the other, providing reasons for why the dust pollution is not their problem.

Outsourcing of the transportation business has made regulating this activity difficult since there are thousands of truck owners to monitor. The rapid growth of the transportation industry has been made possible by the irresponsible lending practices of local banks in the mining areas. Because truck owners are unable to act collectively pressure companies to raise transportation rates, they overload their trucks in order make their business viable while companies turn a blind eye to this practice. Those with the authority to enforce the law are bribed to ignore overloaded trucks and vested interests prevent cleaner methods of transportation of ore from being developed.

When markets and governments fail to address problems faced by the people, the role of civil society becomes vital. Yet, we see that dependence on mining or allied activities for a livelihood decreases the likelihood to actively protest against the problem of dust pollution. A common way to quash dissent is to co-opt dissenters by providing them jobs in the mines, giving them transportation or other related contracts, thus creating stakeholders in the community. It is possible that the age of mining has influenced political activity and civic engagement, as we observe that Cluster I is the most active with regards to complaining about the dust problem, discussing the issue at Gram Sabha meetings and participating in protest marches followed by Cluster II and then III.

Panchayats and mining companies are the two most approached agents when it comes to complaining about air quality problems. In the older clusters (namely I and II) a greater proportions of respondents approach agents other than the Panchayat, suggesting that over time, the local community learns to deal directly with the mining companies as well as higher authorities in the government. Despite having no significant legal authority to address the problem, between 31% - 68% of the respondents approached the panchayat and 39-56.5% of the respondents across the clusters felt that the Panchayat was effective in addressing the problem, suggesting that the Panchayat does wield some power when it comes to addressing this issue.

B Governance case study: Responses to changes in ground water and shortages of water for household use

In this study on governance with regard to ground water management and water supply the following main issues or questions addressed:

- How do mining activities affect groundwater resources?
- How is groundwater managed in the context of mining?
- Who are the main agents involved in water supply?
- What are the alternative sources of water in the study area? Characterisation of alternative water supply
- How do people perceive the main agents involved in water supply?
- What are the key factors that influence decision making regarding water supply?
- What is the community's role in addressing water supply problems?

The problem: Impact of mining on groundwater

Communities living in the mining areas of Goa have traditionally relied on well and spring water to meet their daily needs. However, mining has had an impact on the water table and groundwater has become scarce. Dewatering of mine pits is an important part of mining activities where open cast mining pits are working below the watertable. Dewatering is a process by which groundwater that collects in the pit is pumped out with the help of pumps in order to maintain a dry pit floor. This draining out of groundwater can have an impact on the water balance in the local aquifer.

A TERI (2005) study entitled "Present Status of Groundwater Recharges and Availability in the Mining Watersheds of North Goa" provides information on the condition of ten micro watersheds that fall into Cluster I and II in the study area. By capturing groundwater drafts and recharge for all ten micro watersheds, this study shows that groundwater is a highly stressed natural resource. The table below based on this study, shows that three out of ten watersheds are most-critical or critical while another five are sub-critical. Thus, of the 10 microwatersheds studied, eight are experiencing some level of stress. (TERI 2005)

Table C-B.1 Condition of micro watersheds in North Goa

Water balance classification	No. of watersheds
Most critical (withdrawal > 100% of recharge)	2
Critical (withdrawal = 75-100% of recharge)	1
Sub-critical (withdrawal = 50-75% of recharge)	5
Non-critical (withdrawal < 50% of recharge)	2
Total	**10**

Source. TERI 2005

The lowering of the watertable also leads to reduced availability of well water. During focus group meetings, informal discussions and PRA exercises people in all three clusters complained about shortages of well water or drying up of wells. As well water is one of the key sources of water for household use in rural areas, this poses a problem particularly for women who traditionally deal with household activities involving water.

Results from the governance survey conducted in this project show that the reduced availability of groundwater affects a relatively large percentage of the population and is not limited to a few homes around the mines.

Table C-B.2 Well levels lowered or gone dry

	Wells: Levels lowered + gone dry (%)			
	Cluster I	*Cluster II*	*Cluster III*	*Total*
Summer	59.62	72.82	71.21	70.3
Monsoons	0.00	7.77	1.52	3.5
Winter	21.15	16.50	15.91	17.00

Looking at Table C-B.2 above, it is clear that a very high percentage of people in all clusters have reported well-related problems in the summer. In the summer lowered well levels cannot be attributed only to mining because there is a natural tendency for water levels to drop in this season. During the monsoon the problem diminishes completely in Cluster I and is considerably low in Cluster II and III. This is probably because mining activities come to a halt during the monsoon. The mine pits fill up with rainwater and the aquifer gets recharged. The percentages recorded for winter tell us more about the impact of mining on well levels because the natural tendency towards dryness observed in summer is absent. The change in well levels just after a heavy monsoon can be attributed to dewatering of the mine pits when operations start up again. In winter Cluster I records the highest level of problems relating to wells followed by Cluster II and then Cluster III.

Survey respondents who reported using wells and reported having a water problem were asked what they perceive to be the cause of changes in well water levels. Table C-B.3 below shows that across the study area 50% of those using wells perceived mining to be the cause of change in well water quantity. The largest proportion of respondents perceiving mining as the cause was in Cluster II followed by Clusters I and then III.

Table C-B.3 Cause of change in well water levels – community perceptions

Clusters	Mining and allied activities %	Seasonal %	Other %	Don't know %	N
I	56.00	40.00	8.00	4.00	25
II	63.93	36.07	0.00	1.64	61
III	39.78	45.16	3.23	13.98	93
Total	**50.28**	**41.34**	**2.79**	**8.38**	**179**

The survey results presented above show that a sizable proportion of respondents in the study area report groundwater problems across the three clusters and half of them attribute it to mining and allied activities.

Impact of ground water shortages on women

In order to understand the impact of well water shortages one group discussions were held with women each Cluster. Additional insights were available through ongoing interaction with self-help groups in the study area.

Household activities for which water is required as reported by women in the group discussions are listed below:

- Cooking
- Drinking
- Bathing
- Washing clothes
- Washing dishes
- Cleaning the house
- Paving or layering the floors of the house with cow dung
- Collecting water
- Watering plants and kitchen gardens

With the exception of kitchen gardens where women reported that men are involved in tending the gardens, all the tasks listed above are taken up by women in the household. The difficulties caused by water shortages to women (as reported by the women) in these wards are listed below:

- Women's lives have come to revolve around water. They are unable to plan their days or take up any other activities be it income generation, educational, social or political activities, as they are obliged to wait indefinitely for their water supply.
- Women are forced to manage all their household tasks with very little water. In the dry months when there isn't enough water for cooking, drinking and washing dishes becomes a priority. As a result children and adults can't bathe and teachers at school complain about the children being dirty and unwashed.
- Physical stress increases when conditions are very bad. Women often walk 4 to 5km to the nearest well, stream or spring to wash clothes and bathe. Carrying wet clothes back to their home is tiring and burdensome.
- High levels of anxiety and insecurity because of uncertainty in water supply.
- Sometimes women have resorted to begging for water on the roads. They try to stop passing water tankers and try to convince the driver to let them fill up a few buckets. (Cluster III only)
- In the dry months when water is rationed out from wells or taps fights ensue because of the high levels of stress and anxiety.
- The conditions inside the homes are unpleasant and dirty.
- Supplementary income from kitchen gardens is not possible as there is no water available for the plants.
- As water provided by mining companies is the main alternative source of water in many mining villages, the communities loose a significant amount of leverage with the companies because they depend on companies for basic needs.

Responses to changes in ground water

In an area where traditional sources of water (such as groundwater) are stressed as a result of mining, good governance demands that alternative sources of water be adequately supplied to meet the daily needs of the community.

The following sections look at the responses by the different agents to the water supply problem. First, we look at the legal framework within which groundwater is managed and attempt to characterise groundwater management in the context of mining in Goa. In the face of depleted groundwater resources, we then look at alternative sources of water supply focusing on the agents responsible at different levels in the government. We also characterise the role of civil society in addressing issues related to water and bring out the role of women in dealing with water supply problems.

Groundwater management

The Department of Water Resources is responsible for managing groundwater and managing surface water bodies. In terms of ground water, this department is empowered by the Goa Goa Ground Water Regulation Act 2002 (Government of Goa 2002). Some of the main features of this act are as follows:

- Clearly prioritizes drinking water supply over other uses of groundwater
- Provides the authority to restrict groundwater withdrawals in ways that threaten drinking water sources and in critical areas (watersheds) where groundwater is deemed to be overexploited
- Recognizes the need for limits on the transport of water[6] by surface transport or by pipeline in over exploited areas

While this framework provides considerable powers for the management of groundwater, its enforcement is problematic. For one, enforcement of the Act is dependent on data that identifies watersheds that are critical (where withdrawals exceed recharge). At the moment the Central Ground Water Board monitors only 54 wells across the entire state of Goa (water columns are checked quarterly) which is not enough data to assess the conditions of individual micro-watersheds. According to government representative interviewed, so far, there have been no studies taken up by the state government to assess the impact of mining activities on groundwater and the state government has no plans to do so in the near future. Thus, in the absence of adequate data, the enforcing authorities cannot enforce the Act. According to officials from the Water Resources Department, ground water monitoring and digitisation of this data has begun under a new World Bank funded project. Through this project the State Water Resources Department plans to develop a monitoring network of wells but none of the chosen locations are in the mining areas. The focus seems to be almost exclusively on coastal groundwater.

A potential source of data on the impact of pit dewatering is the Environmental Impact Assessment submitted by each company prior to beginning operations or expansions/ extensions of the mine lease. The Environmental Impact Assessment (EIA) reports

[6] The Goa Ground Water Regulation Act, 2002 states, 'No person shall transport groundwater from a source of water in a scheduled area more than 30 000 litres annually, by any means of surface transport or by pipeline without the permission of the Ground Water Officer.'

submitted by mining companies ought to provide a projection of groundwater use and depletion. According to Department officers, however, these studies, at times, fail to capture the impact on areas within a short radius around the mine pit which is where wells go dry. This may be because the groundwater studies tend to focus on the larger watershed, rather than the micro watershed. Additionally, there is no routine data sharing between the Indian Bureau of Mines, the department overseeing the EIAs, and the Department of Water Resources that is supposed to implement the Groundwater Act.

In general, officers with the Water Resources Department seemed to suggest that impact of mining on groundwater is well know, but is not a big enough problem to merit any attention. It was suggested that since the problem is not wide-spread it is unimportant and not necessary to address. (Yet, in the governance survey conducted for this project, 17 % of respondents across the study area reported that the water level in their wells had lowered or wells had gone completely dry in winter, a season in which lowered levels are more likely to be associated with mining activity than seasonal changes.)

Department officials also expressed the view that mining has created jobs and has benefited the community immensely. Therefore the community has no right to complain about the negative impacts of mining. (While this argument is problematic, to say the least, even by its own logic the numbers do not bear out. In the governance survey conducted, 38.24% of respondents stated that they or their family members are employed in mining and allied activities while 61.31% are not. Thus, a large percentage of people facing water problems may not be benefiting from mining jobs.)

Water Resources Department officers tend to take action only when they receive complaints about groundwater shortages. The department takes a more conciliatory approach where in such cases they ask companies to take up additional water harvesting measures (eg. artificial recharge pits) and request them to provide tanker water to local community members facing water shortages.

Provision of alternative sources of water

As mining has had an impact on the water table and groundwater has become scarce, the state and mining companies have responded by providing alternative sources of water. Local communities have come to depend upon two or three different sources of water.
The main agents involved in management household water supply are as follows:

- Panchayats: As representatives of the village Panchayats are responsible for making applications to the PWD for tap water supply. They also provide local residents with income certificates to avail of the free tap scheme (explained later) and represent the community / present community opinions or problems to other agents. In terms of groundwater, they are responsible for the maintenance of public wells.
- Public works department: This department is responsible for laying and maintaining the pipe network for water supply and for day-to-day provision of tap water.
- Mining companies: Provide water by tankers to various local villages that are stressed.

- Ministers of the Legislative Assembly (MLAs): Use their good office to get works sanctioned and implemented speedily.
- Landlords: They have no formal role to play but can obstruct the procedure to get taps installed by refusing to allow pipes to pass over their land.
- Local communities: Local communities also play a role in creating change by pushing for better practices or more responsiveness from state agents and companies. Their participation in civic life has an impact on services available in the region.

The two main alternative sources of water in the study area are tap water provided by the Public Works Department (PWD) and water supplied by tankers by mining companies. In this section we characterise alternative water supply in each cluster. The kind of alternative water in each Cluster tells us about the responsiveness of the state to water shortages in the mining areas.

❖ **Tap water**

The table below shows the percentage of respondents in each Cluster using tap water at home.

Table C-B.4 Percentage of rural population using private taps

Cluster	Rural respondents using pvt taps (%)	N
I	75.00	52
II	59.01	161
III	56.99	193
Total	**60.10**	**406**

From the above table it is clear that a greater percentage of respondents in Cluster I have taps (75%). The percentage of people having taps in Cluster II and III is similar (57% -59%) but about 15% lower than Cluster I. Considering the study area is rural, these numbers suggest that the tap network is quite extensive and show that Panchayats and the PWD have responded to the problem of lowered well water levels. The availability of taps at home show that the Panchayats and the PWD have responded the most in Cluster I as compared to Cluster II and III. In addition to having taps, however, the regularity of supply is also important.

During group meetings, women in the study area had complained about erratic tap water supply which is borne out through the survey. Respondents were asked whether they received tap water daily. The table below shows that in the study area reporting of irregularity is very high (67.6%) summer, drops to 21.7% in the monsoon and rises again to 29.5 % in winter.

Table C-B.5 Percentage reporting irregular tap water

Cluster	Tap water – irregularity / no water			
	Summer	*Monsoon*	*Winter*	N
I	58.97	17.95	15.38	39
II	69.48	31.58	37.89	95
III	69.10	14.55	27.27	110
Total	**67.62**	**21.72**	**29.51**	**244**

Table C-B.5 above shows that in all seasons the largest percentage of respondents reporting irregularity are in Cluster II. Cluster I is better of than Cluster III, except in the monsoons where a higher percentage of people in Cluster I report irregularity. Interestingly, in Cluster I a higher percentage reported irregularity in the monsoon than in winter, which is contrary to expectations.

Over all it can be seen that Cluster II is the worst off in terms of regular daily water supply followed by Cluster III and then Cluster I.

Regularity in terms of timing

Women in focus group discussions had also complained that they do not receive water at the same time daily. They claimed that they are forced to stay at home all day and they can't take up other activities as a result. In order to verify the extent of this problem we asked whether timings for water supply were regular or not.

Table C-B.6 Percentage reporting irregular timings

Cluster	Tap water – irregular timings			
	Summer	*Monsoon*	*Winter*	N
I	46.15	25.64	23.08	39
II	64.21	38.95	43.16	95
III	59.09	17.27	25.45	110
Total	**59.02**	**27.05**	**31.97**	**244**

Reporting of irregularity was high across the study area (Table C-B.6). A cluster-wise breakdown of results shows that, Cluster II fares worst in term of regularity of timing in all three seasons. Cluster I fares better than Cluster III, except in the monsoon where 25% of Cluster I reported irregular timings as opposed to 17% in Cluster III.

While tap water is replacing traditional sources, namely well water, it is important to note that tap water supplied by the PWD is not free[7] whereas there are no costs associated with well water. In the survey, people were asked whether they felt their monthly bills were reasonable/affordable or expensive. The table below (C-B.7) shows that more than half the respondents in Cluster III found the bills expensive followed by Custer II with just under half the respondents. In Cluster I 36% of respondents found water bills expensive.

[7] The government has a scheme whereby the government pays for the installation of a tap and water meter for families with an income of less than Rs. 25,000 per annum however monthly water bills need to be paid by the family. Families that avail of this scheme save on average Rs. 1500 on the cost of the installation.

Table C-B.7 Affordability of tap water

Affordability of tap water			
Cluster	**Expensive**	**Affordable**	**Don't know/ No response**
I	35.85	60.38	3.77
II	42.55	47.87	9.57
III	53.97	35.71	10.32
Total	**46.52**	**44.69**	**8.79**

While tap water is perceived as expensive by close to half the respondents, the Public Works Department is simultaneously in the process of removing public taps across the state including mining areas as part of a state policy to stop free supply and enhance revenues. Public tap water is provided free of cost to the consumer and is an important source of water for people who can't afford private taps. Table C-B.8, below shows the percentage of people who reported using public taps in all three seasons in each Cluster (along with other sources of water). Approximately 18% of respondents in Cluster III are dependent on public tap supply while in Clusters I and II approximately 10% of the study population is using public taps.

Table C-B.8 Public tap usage

Cluster	Use public taps (%)	Don't use because recently removed (%)	N
I	9.86	27.14	70
II	10.63	22.98	161
II	18.01	18.95	211
Total	**15.84**	**31.07**	**442**

Additionally, the table above tells us that 31% of the respondents don't use public taps because they were recently removed. Interestingly, the highest proportion was in Cluster I followed by Cluster II and then Cluster III. This highlights the state's attention (or lack of attention) to equity in planning and policy.

❖ Tanker water

The survey also provided information on tanker supply in each cluster. Table C-B.9, below, shows that Cluster II is highly dependent on tankers (60% -83%) and more so than any other cluster in all seasons. Interestingly, tanker supply is relatively high even during the monsoons in Cluster II.

Table C-B.9 Use of tanker water

Receive tanker water daily or every alternate day (%)			
	Cluster I	***Cluster II***	***Cluster III***
Summer	28.58	83.78	78.82
Monsoon	14.29	60.81	4.71
Winter	14.29	60.81	14.12

The provision of tanker water to large percentages of the population in the study area as a whole suggests that mining companies and Panchayats are making an effort to respond to the

communities' water problems. One cannot conclude, however, that companies and Panchayats are more responsive in Cluster II because a greater percentage of people get tanker water. Rather the high percentage of tanker supply could be an indication of higher levels of water stress.

While tanker water supply is an effective way to reduce short term water stress, it is not sustainable in the long run and calls into question the relative importance given to issues of sustainability in terms of alternative water supply. In this survey there were 165 respondents who said that they had no water problems. Of those reporting no water problems at all, 16% said they receive water through water tankers suggesting that for sections of the local community being dependent on tanker water is not perceived as a problem and the sustainability of their water source is not a consideration.

From the survey we can conclude that while private taps were found in nearly 60% - 75% of the surveyed households, they were reported as being unreliable in terms of daily supply and supply timings, especially in the summer months, when water stress is highest. Additionally, even though alternatives like tap water exist, they come at a cost as opposed to well or stream water. It is largely felt that private taps are an expensive option, even as the State government, as a policy, is decommissioning pubic taps. Additionally, a large proportion of respondents were dependent on tankers for water supply, which is not a sustainable option in terms of water supply

Community perceptions of agents and community participation

In order to identify differences in responsiveness and efficiency of major agents by cluster, and to assess how active the local community is in terms of pushing for change or for better services, residents in the study area were asked who they approach for water problems, what their main complaints were and their opinions about various agents they approached. This was done through the household survey.

From the total sample of 442, 277 respondents claimed to have some water related problem. From these, 267 answered questions relating to whether they approached any agency or not. While 10 people (3.61%) did not respond to the question, 56 respondents (or 20.97%) said that they approached no one, which implies that one out of every five persons is unlikely to complain about water problems that they might face.

Table C-B.10, below, shows the kinds of problems or issues respondents complained about. Between 80% and 99% of respondents complained about tap water supply, including irregularity, insufficiency of water, broken or leaking pipes etc. Between 15% and 20 % of people complained about lowered wells water level (which is similar to the percentage of people reporting well water problems in winter). A relatively low percentage of respondents complained about tanker water supply.

Table C-B.10 Problems reported (%)

Cluster	Tap related	Well related	Tanker related	N
I	99.99	17.65	0	34
II	81.31	20.56	12.15	107
III	96.75	15.45	3.25	123
Total	**90.9**	**17.8**	**6.44**	**264**

Table C-B.11 below shows that a considerable percentage of respondents in all three clusters approached their Panchayat for water related problems with Cluster III reporting the highest percentage followed by Cluster II and then I. Despite the Panchayat's role in water supply being limited, the fact that a large percentage of respondents in each Cluster approach them suggests that local communities have faith in their Panchayat's ability to solve their problems and it is an important agent from people's perspectives. The fact that the largest percentage of respondents approaching the Panchayat were in Cluster III, followed by Cluster II and I suggest, that with age of mining it is possible that people are less inclined to approach their Panchayat and more inclined to go to approach a greater variety of agents.

In Cluster I the second most approached agent is the PWD followed closely by mining companies. Similarly in Cluster III the second most approached agent is the PWD, however, very few people (only 4.9%) reported approaching mining companies. In Cluster II, mining companies are approached 10% more than the PWD.

Table C-B.11 Agents approached for water problems

Cluster	*Panchayat*	PWD	Mining Co.	Others	N
I	47.1	23.5	20.6	8.8	34
II	58.9	12.1	22.4	6.5	107
III	68.3	21.1	4.9	5.7	123
Total	**61.7**	**17.8**	**14.0**	**6.4**	**264**

In the survey, those who reported approaching a particular agent were asked what kind of response they got from that agent in terms of attitude/concern shown and in terms of whether their problems were solved (effectiveness).

The table below (C-B.12) shows that in the study area in terms of attitude mining companies fared best (86.6%) followed by Panchayats (79%) and finally the PWD (73%).

Table C-B.12 Attitude

Cluster	*Panchayat*		PWD		Mining companies	
	Some/ a lot of concern (%)	*N*	*Some/ a lot of concern (%)*	*N*	*Some/ a lot of concern (%)*	*N*
I	50.0	16	62.5	8	80.0	5
II	69.8	63	41.7	12	91.7	24
III	91.5	82	92.3	26	83.3	6
Total	**78.9**	**161**	**73.9**	**46**	**86.6**	**35**

As seen in Table C-B.13, cross the study area, all three agents were seen to be effective by similar percentages of people (between one and two percentage point difference). The greatest proportion of people found the PWD (63.8) to be effective followed by mining companies (62.9) and then the Panchayats (61.5).

Table C-B.13 Effectiveness

Cluster	*Panchayat*		*PWD*		*Mining companies*	
	Effective	*N*	*Effective*	*N*	*Effective*	*N*
I	50.0	16	62.5	8	85.7	7
II	56.5	62	46.2	13	50.0	22
III	67.5	83	73.1	26	83.3	6
Total	**61.5**	**161**	**63.8**	**47**	**62.9**	**35**

Looking at agents across the three clusters we can see that the Panchayats fare best in Cluster III followed by Cluster II and then I in terms of attitude and effectiveness.

The PWD fares best in Cluster III followed by Cluster I and then II. The lowest satisfaction (in terms of attitude and effectiveness) with the PWD in Cluster II makes sense considering the levels of irregularity reported in the survey.

While these tables highlight the attitude and effectiveness of agents, they also tell us a lot about people's expectations in the three Clusters. In general, greatest percentage of people satisfied with all three agents seem to be in Cluster III followed by Cluster II and then Cluster I suggesting that with increasing age of mining it is possible that people have higher expectations is terms of basic amenities and in terms of attitude of service providers.

In terms of attitude mining companies fare best in Custer II followed by Clusters III and then Cluster I. A greater percentage of people in Cluster I found companies effective followed by Cluster III and then Cluster II.

The complaints/ demands made of each of these three key agents varied greatly to the extent that not all demands/ complaints made were solvable directly by that agent. Table C-B.14 below shows what percentage of complaints made to each of these agents was actually related to something within their jurisdiction. Only between 16% and 23% of demands to the Panchayat were related to applications for piped water for the village or for free installation of taps. The rest were related to the functioning of the piped network, lowered well levels, erratic tankers etc. regarding which the Panchayats cannot act themselves but can only approach/pressure another agent. Considering this the percentage of people finding the Panchayat effective in solving problem is very high.

Table C-B.14 Percentage of complaints that are within agent's jurisdiction

Cluster	*Panchayat*	PWD	Mining Co.
I	23.81	66.67	75.0
II	23.38	81.25	76.0
III	16.83	81.82	85.7
Total	**20.10**	**79.31**	**77.5**

Factors influencing decision making

Having looked at water supply across the three clusters the study attempted to explore the factors that influence decision making among the key agents through qualitative data. Water supply in four hamlets (administrative wards) across the study area was analysed. Here we chose hamlets in each Cluster that were known to have a water problem or know to have very good water supply.

Ward	Cluster	Characteristics
Ward A	I	Well levels dropping, 24-hour tap supply, public taps phased out
Ward B	I	Well levels dropping, no taps, daily tanker supply
Ward C	II	Wells completely dry and filled up with mud, no taps (public or private), tankers twice a day
Ward E	III	Wells drying, public taps, very few private taps, no tanker supply

As stated earlier, at the local level there are several agents involved in decision making regarding water supply (Panchayats, PWD, mining companies, MLAs, land lords, community members).

In each ward studied several factors influenced decisions regarding water. Below are the most important factors that emerged across the study area:

- **Political affiliations of the panchayat**

While Panchayats and Panchayat members are not supposed to have any political affiliations, in fact many Panchas are often affiliated to major political parties in the state. At one of the wards surveyed the representative found it difficult to get any development taken up in his ward because he was in a minority within the Panchayat. Similarly, PWD staff stated that applications from Panchayats affiliated to the ruling party in the state were treated with more urgency and were more quickly approved. Thus, political affiliations had a strong impact on responsiveness of various agents.

- **Village disputes/politics**

In a particular ward surveyed the residents were themselves divided. Thus, the more powerful group ensured that tankers supplying the ward stopped outside their houses. In the same ward, the landlord refused to allow water pipes to be laid over his land thereby preventing the whole ward from having tap water supply despite wells going dry. In such instances the Panchayat does have the power to intervene, but in this case the local representative was related to the landlord which prevented him from taking action against a relative. In this case responsiveness was compromised because of personal affiliations and village politics.

- **Using public office for private gain**

In an interesting case, an elected representative owns a fleet of tankers that are hired out by mining companies to supply water. Company representatives have alleged that there is some level of pressure to hire water tankers from this person as he is powerful and can disrupt the daily working of mines. Some of the wards in this village face serious water stress. It was hinted at by some that the representative may be subtly blocking a long term solution to the problems because it would affect his tanker business. In this example personal monitory gains play a big role in an elected representatives decisions.

- **State of infrastructure**

The proximity of a village or hamlet to the main water pipeline or to a reservoir had a big impact on the regularity of water supply. The PWD infrastructure is such that villages closer to the reservoir get better supply. One of the villages surveyed which is adjacent to a reservoir receives close to 24 hours of water throughout the year. Similarly, villages located towards the end of main water pipelines received less water and timings were more irregular.

- **Political pressure**

In some cases pressure on the PWD by Ministers of the Legislative Assembly (MLAs) or other influential politicians made a significant difference in terms of how quickly an application for laying of pipes or fixing taps was processed.

- **Economic interests**

The PWD started removing all public taps across the state two years ago. They claim that public taps are often leaking and poorly maintained and because the water supplied is free it tends to be wasted. They also stated that free supply of water is a wasted opportunity to earn revenue. Several public taps have been removed across the study area even though not all residents can afford to pay for a private tap connection and monthly water bills. Interestingly, in the ward receiving 24 hour tap water supply, some residents stated that they could not afford the monthly bills and hence have not applied for a private tap. Thus, despite good supply the principle of equity has been ignored.

This study also viewed the local community as an agent involved in change. In the following section the community's participation in addressing water issues is addressed.

The community's role in solving water problems

Through the survey was also attempted to understand how and to what extent the community is participating in civic life and through which forums. The survey focused on the following:

- Complaining behaviour
- The Gram Sabha
- The use of protest
- Local level institutions

Complaints

Data analysis also throws light on the level to which people in each cluster are engaged in civic life and are willing to move the system for redressal of their problems. Table C-B.15, below, shows that of those who had water problems, a relatively high percentage (76.17 %) of

the respondents across the study area made the effort to resolve their problems by approaching companies or government. A Cluster-wise analysis suggests that Cluster III is least active with 73% of people having problems seeking redressal followed by Cluster I with 75% of people seeking redressal. Cluster II is the most active with 80% of respondents with water problems having approached government or companies. The high percentage of people complaining in Cluster II may be result of greater levels of water stress in this Cluster.

Table C-B.15 Complaints regarding water problems

Cluster	No of people reporting water problems	No of people complaining	No. of complaints	Percentage of people complaining (%)	Ratio of cmplaints to people complaining
I	32	24	34	75	1.41
II	102	82	107	80.39	1.30
III	143	105	123	73.43	1.17
Total	**277**	**211**	**264**	**76.17**	**1.25**

Table C-B.15, above, also provides a ratio of the number of people complaining and the number of complaints. While respondents in Cluster I may be a little less likely than respondents in Cluster II, to make a complaint (as seen in the table above), the table below shows that individuals in Custer I who do take action are more active and are likely to complain repeatedly or approach more than one agent. In Cluster II the 80% with problems who are complaining are also likely to complain more than once but are slightly less active than people in Cluster I. People in Cluster III who do complain are least active relative to the other two clusters. On the other hand, higher civic activity in Cluster I followed by Cluster II and III may be a result of the age of mining.

Gram Sabha

Through the survey we also tried to estimate how actively the community uses the Gram Sabha (village assembly) to discuss or address village problems; in this context, water problems. Table C-B.16, below, shows the number and percentage of people in each Cluster attending the Gram Sabha regularly and their perception of how often water is discussed in the Gram Sabha.

Table C-B.1G Discussion of water problems in *Gram Sabha*

Cluster	Regularly attending *Gram Sabhas* n (%)	Frequency with which water related problems are discussed at the *Gram Sabha*			N
		Rarely / Never n (%)	*Sometimes / Regularly* n (%)	*Don't Know / No response* n (%)	
I	14	5	6	3	14
	26.92	35.71	42.85	21.43	
II	18	6	8	4	18
	11.18	33.33	44.45	22.22	
III	12	3	3	6	12
	6.22	25.00	25.00	50.00	
	44	**14**	**17**	**13**	**44**
Total	10.84	31.82	38.63	29.55	

Table C-B.16, above, shows that regular Gram Sabha attendance is highest in Cluster I, followed by Cluster II and III. The table also shows that regular discussion about water shortages in the Gram Sabha is similar in Clusters I and II (about 43%) but much lower in Cluster III at about 25%. Again these numbers suggest that the age of mining does play some role in terms of people's participation in solving problems.

Protest (Demonstrations)

Table C-B.17 shows that from all those who had water problems there were about 11.5% respondents who participated in demonstrations. The highest percentage of people demonstrating are in Cluster II (13.6%), followed closely by Cluster I (12.9 %). Only 9.79% of people with water problems in Cluster III participated in demonstrations. Greater protests in Cluster II may be linked to the greater extent of water stress reported by respondents.

Table C-B.17 Participation in protest demonstrations regarding water shortages (%)

Cluster	*Yes*	*No*	*Don't Know / No Response*	*N*
I	12.90	77.42	9.68	31
II	13.59	83.50	2.91	103
III	9.79	76.92	13.29	143
Total	**11.55**	**79.42**	**9.03**	**277**

Local level institutions

As well-functioning local level institutions can be a powerful platform from which to address community issues, respondents were asked whether there are any local level institutions taking up village issues; in this case water shortages.

Table C-B.18 Discussion of water problems in other forums

Cluster	Village Devt. Groups	Womens' Clubs/ Self help groups	Other	No	Don't Know/ No response	N
I	3.23	16.13	0.00	48.39	32.26	31
II	1.94	6.79	0.97	57.28	33.01	103
III	3.50	8.39	4.90	60.14	23.07	143
Total	**2.89**	**8.66**	**2.89**	**57.76**	**27.80**	**277**

Table C-B.18, above, shows that only 14.44% of respondents who stated that they had a water supply problem reported taking up water issues in any other forum. Collectively, Women's Clubs and Self Help Groups are the most common forums to discuss water related issues. In the "other" category, people mentioned the Gram Sabha and reported talking about water problems with other residents of the village/friends and neighbours. Looking at all other forums together, people in Cluster I are most active about discussing water related issues in other local forums followed by Cluster III. Cluster II seems to be least active in this context.

From the tables presented in this section we can see that a large percentage of respondents in the study area and in each cluster are involved in complaining or approaching various agents regarding water supply. Yet, the study area seems to have very few civil society groups where

they discuss or take up water related issues. Field experience in the study area also tells us that there are generally very few local level institutions in the study area. Thus, while complaining behaviour was reported highly, general participation in civic life seems to be low. In terms of age of mining, a clear pattern suggesting that Cluster I is the most active followed by Cluster II and III does emerge.

Given that the women in the local community are most inconvenienced by water shortages the study attempted to assess the extent to which women are involved in civil life.

The Indian constitution has specifically reserved 1/3rd of all elected posts at the village level for women, with the intention of making women's issues and problems part of the village development agenda. Yet, women Panchas (elected representatives at the village) we interacted with during focus group discussions claimed they didn't take up any special issues related to women but worked towards village development issues in general. Addressing general issues of village development or not drawing any distinction between general and women's issues seemed to be their way of asserting equality between the two sexes.

Through the survey we also attempted to assess women's awareness about the village assembly.

Table C-B.19 Awareness about the *Gram Sabha*

	Male		Female		Population	
Are you aware that a Gram Sabha is held in your village four times a year?	***Count***	***Percent (%)***	***Count***	***Percent (%)***	***Count***	***Percent (%)***
Yes	153	75.37	132	62.86	285	69.01
No/Don't Know	50	24.63	78	37.14	128	30.99
No response	15	6.88	13	5.83	28	6.35
Total	**218**		**223**		**441**	

Table C-B.19 shows that 37% of female respondents claimed they were not aware about Gram Sabhas or the fact that they are regularly held in their villages. Similarly, the table below (C-B.20) shows that as many as 45% of women respondents reported that they had never been to a Gram Sabha.

Table C-B.20 *Gram Sabha* attendance

	Male		Female		Population	
Do you attend your village Gram Sabha?	***Count***	***Percent (%)***	***Count***	***Percent (%)***	***Count***	***Percent (%)***
Always	28	13.79	16	7.17	44	10.73
Sometimes	84	41.38	78	34.98	162	39.51
Once-twice	14	6.90	12	5.38	26	6.34
Never	77	37.93	101	45.29	178	43.41
No response	15	6.88	16	7.17	31	7.03
Total	**218**		**223**		**441**	

Participants in the survey were asked whether the men or women in the family are involved in making complaints regarding water or air problems. Table C-B.21 shows that only 5% of respondents said that women in their families are involved in complaining and 9% said both men and women complain.

Table C-B.21 Do men or women complain?

Who Complains?	Count	Percentage
Men	153	35.83
Women	22	5.15
Both	40	9.37
Never Complained	144	33.72
Don't know	68	15.93

Similarly, only 4% of respondents reported that women in their families are involved in protests and 6% said that both men and women participate.

Table C-B.22 Male/female participation in protest

Participation	Count	Percentage
Men	55	13.32
Women	16	3.87
Both	27	6.54
Never participated	233	56.42
Don't know	82	19.85

The data presented above suggests that women are not strongly involved in civic life across the study area. While women seem to have very little presence in formal spheres, there is some evidence that they do influence decisions through informal channels. In one of the water stressed wards visited, women reported that the village development committee had convinced the mining company operating in the area to provide an extra tanker of water daily making women's lives easier and more secure. They also convinced companies to provide a water storage drum to each family in the ward. While there are no women members on this village development committee, women have been successful in getting their demands met. Similarly, women have often mentioned that they don't attend Gram Sabhas or other village meetings because someone else in the family will represent them.

Interestingly, women in micro-credit/ self-help groups in the study area have begun to take action regarding problems faced by them in the village. One of these groups took the initiative to invite their local representative to a meeting and questioned her about her efforts to resolve their water shortage problem. The fact that women are using civil society groups to voice their concerns also stands out in Table C-B.18 (above). This suggest that given the right exposure and opportunity women are interested in playing a more active role in resolving water problems or other problems that affect their lives.

Summary

- Problems with groundwater are relatively widespread across the study area and not limited to just a few homes in the mining areas.
- Women are most affected by water shortages as they are responsible for all the household chores requiring water.
- In the winter season (when the impact of mining is felt most strongly) wells in Cluster I seem to be the most stressed followed by Cluster II and then Cluster III.
- Cluster II emerges as the most stressed in terms of regularity of tap water supply.
- The largest percentage of respondents receiving tanker water is in Cluster II
- While tanker water is necessary in the short run, it is not a sustainable response to the problem of depleting groundwater.
- The high percentage of people in all Clusters having taps suggests that the Panchayat and PWD have responded to groundwater shortages in the study area.
- However, tap water supply is irregular and expensive and has resulted in insecurity and an extra burden on low income groups.
- In terms of responsiveness, most people found companies showing concern for their water problems followed by the Panchayat and the PWD.
- In terms of effectiveness a roughly equal percentage of respondents reported the PWD, companies and Panchayats to be effective.
- Factors that influence behaviour /decision making of various agents responsible for ground water management and water supply were similar in all three Clusters.
- A high percentage of people are involved in complaining across the study area.
- In terms of complaining about/ discussing water problems in various forums, Cluster II is slightly more active than Cluster I. (Possibly because of greater stress.
- Participation in civic life in general (Gram Sabha participation, local level institutions, level of activeness of individuals) is higher in Cluster I than Cluster II.
- Cluster III is the least active in all ways.
- Women across the study area are not very active in civic life, especially through formal spheres.
- Women do have agency and do influence decision making in informal way.
- Given the right exposure and opportunities women are interested in playing a larger role in decision making.

Conclusions

Mining activities have had an impact on ground water bodies in the study area. Looking at the responses of various agents in the study area and their attitude to water shortages, we see that several principles of good governance are absent in terms of decision making and implementation of decisions.

The data presented in this section shows that the state and companies together have been responsive to shortages of water but their attention to effectiveness and equity has been low. While the state is involved in addressing the impacts of mining on ground water, their refusal to acknowledge problems with ground water have precluded any possibility of a response through improved policies or practices towards better management of ground water.

While the responses of various agents and the factors that influence their behaviour has been similar across the three Clusters, this data shows that the age of mining may have an influence on people's expectations regarding basic needs and regarding responses from various agents in the study area.

According to the cluster (age of mining) hypothesis, people in Cluster I are likely to be more politically active than those in younger clusters because presence of mining over time tends to have a positive effect on a variety of determinants of civic and political participation, such as income, education, infrastructure etc. Cluster I being better off in terms of water supply and in terms of political activity supports the Cluster theory. The slightly higher participation reported in Cluster II may well be related to higher levels of water stress reported by people in this cluster. Cluster III still lags behind Cluster I and II in terms of having a politically active population. This could be attributed to the fact that mining has been present for a shorter time (cluster theory) coupled with the fact that they seem to have slightly less water problems than people in Cluster II.

Recommendations

Ground water management

- There need to be more studies and more data generated on groundwater in the mining areas, both from an anthropocentric and an ecological point of view.
- Legislation on groundwater needs to be revisited to see how the impacts of mining can be taken into account without stopping mining activities all together.
- There needs to be more data sharing and collaboration between departments in order to tackle this issue.
- There is an urgent need for further awareness and capacity building among government workers about responsible mining and the role of government in supporting companies to comply with regulations or move even beyond the legislative framework.

Alternative water supply

- In wards where alternative water supply is very poor or where tankers are the only source of water, more localised solutions need to be sought and invested in, such as rainwater harvesting.
- Water removed from mine pits could be treated and supplied to local communities.
- The suitability of abandoned or exhausted pits as water storage sites could be evaluated.

Functioning of *panchayats*

- More power and funding to Panchayats to address water supply problems at the local level
- Capacity building of Panchayat members
- Clear policy on action against landlords that prevent people's access to basic necessities from being

C Health data management case study

Introduction

Using the Ecohealth approach this project has highlighted some ways in which environmental change in the context of mining has impacted human health, specifically respiratory health. This component of the study is concerned with the state's response to an emerging health problem in the study area. Health outcomes for an individual or community health status are dependent on biological characteristics, behaviour, the presence of environmental stressors and importantly access to good health care. In order to respond to changing health needs of a community through targeted health services and through an improved health policy there is a clear need for robust data that can highlight emerging and potential health problems. The need for sound health data is well recognized in literature (WHO 2006, OECD 2005, Coffey, et. al. 1997, Coye et. al., 2003) and also recognized in the National Health Policy 2002.

As the health study in this project focuses on respiratory health researchers attempted to gather secondary data on respiratory morbidity from the Directorate of Health Services. However, in most cases data gathered could not be used in the health study because the formats followed were inconsistent or data was missing for several months from some of the health centres in the study area and across the state (Formats are provided at the end of this case study). Given the project's focus on governance, in this component of the project we have attempted to study how data is collected and managed for the study area. Specifically this component has attempts to:

- Identify problems with the functioning of the current data management system
- Comment on the structure and purpose of the system
- Provide recommendations for change

As the bulk of health care facilities in the study area fall within the primary health care level, this component has focused on health data emerging from the primary level health facilities.

Background

The Central Bureau of Health Intelligence (CBHI) (a department under Ministry of Health and Family Welfare) is the national agency responsible for compilation, analysis & evaluation and dissemination of health statistics. The CBHI has developed standardized formats or proforma for data collection to be used by State governments across the country. Additionally, training programmes for medical statistics personnel and technical assistance is provided in each state. This agency also maintains liaisons with research institutions in India and abroad to promote research in statistics. In addition to statistics on general morbidity, the central government compiles data linked to a variety of national health programmes implemented by the states.

The nodal agency in Goa responsible for collecting, compiling, analyzing and disseminating health data is the Health Information Bureau attached to the Directorate of Health Services. This agency is the link between the state and CBHI. The Health Information bureau in Goa gathers health status data on the following:

- Communicable diseases and vaccine preventable diseases (format provided at the end of this case study)
- Non-communicable diseases (this includes general morbidity data)
- Cholera and plague

Additionally, data related to a variety of national health programmes that are implemented in the state is also compiled.[8] Presented below is a list of national programmes implemented in Goa:

- National Family welfare programme
- National vector borne disease control programme
- National Filaria control programme
- National leprosy eradication programme
- Revised national Tuberculosis control programme
- National programme for the control of blindness
- Sexually Transmitted Diseases
- National Iodine deficiency disorder control programme and
- Integrated disease surveillance programme (related to both communicable and non communicable diseases)

Within the state data flows from health centres at the lowest level (village level) to the Directorate of Health which is the highest level as shown in the diagram below.

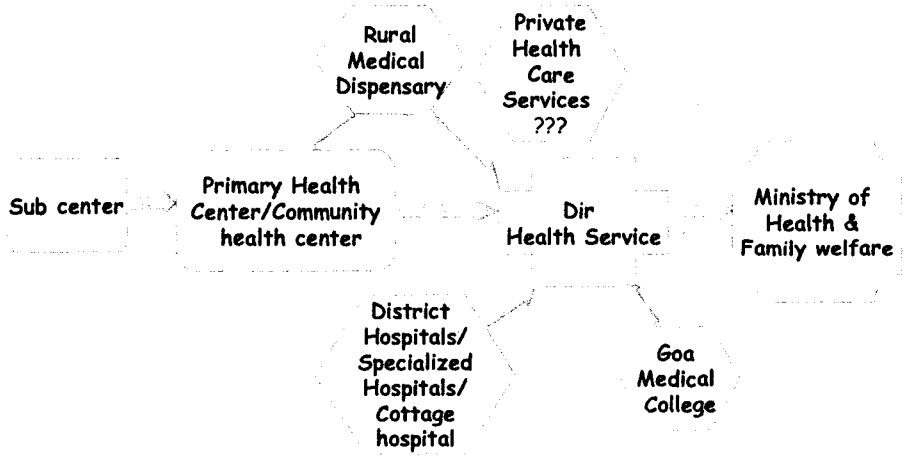

Figure C-C.1 Data collection and reporting structure

There are totally 62 health care institutions across the state of Goa that are supposed to report morbidity data to the Health Intelligence Bureau (HIB) as presented in Table C-C.1.

[8] In Goa the national health programmes are implemented through programme officers These programme officers directly report to the national programme officer in charge of the following schemes.

Table C-C.1 Health care facilities reporting to the Health Intelligence Bureau

Health Care Facility	Number in Goa	In study area
Primary Health Centres	19	3
Community Health Centres	5	1
Hospitals	5	-
Urban Health Centres	4	-
Rural Medical Dispensaries	28	3
Sub centres	172	23
Medical Dispensary	1	
Total*	**62**	**7**

Note* The total number of health facilities reporting to the Directorate of Health services does not include sub centers as they do not report directly to the HIB. Instead they report to Primary or Community Health Centres from where the data is forwarded to the HIB.

In the study area there are 23 Sub-centres that are supposed to submit data to the Primary Health Centres (PHC)/ Community Health Centre (CHC) to which they are attached.

Analysis of the data collection and management system has focused on the lowest or primary tier of the health care system (PHCs, CHCs, Sub-centres) as all the public health care facilities in the mining region fall within this category.

Collection and compilation of data

At the peripheral level of care the Sub-centers (SC) and Rural Medical Dispensaries (RMDs) located at the village level, gather general morbidity data based on outpatient visits and data pertaining to national programmes implemented at this level (eg. vaccinations, family planning etc.) Multipurpose health workers are supposed to collect data to prepare reports on the national programmes, a disease report and a health education activity report as part of their regular duty. The Medical Officers (who are doctors) collect general morbidity data at the time of the weekly consultation hours conducted at the Sub-centres. This data is sent to the Primary Health Centre (PHC) or Community Health Care (CHC) to which they are attached. In the absence of the medical officer the Multi purpose health worker (MPHW) may collect this data.

At the PHC/ CHC, records are maintained for all inpatients and for all outpatient visits and for care provided under the national health programmes. This data, along with data received from satellite Sub-centres is compiled and sent to the Directorate of Health Services (DHS). There are approximately 6-8 Sub-centres attached to each PHC or CHC. Additionally, there are 1 or 2 Rural Medical Dispensaries (RMDs) attached to some PHCs/CHCs.

At the secondary and tertiary level of health care, the district hospitals, specialized hospitals and state hospital keep records for all inpatients and outpatients and are required to provide this data to the Directorate of health services (DHS).

At the Directorate of Health Services (DHS) the Health Information Bureau compiles data from all the various health care institutions and sends it to the Central Bureau of Health

Intelligence. Simultaneously, the programme officers of the different national health programmes send data to the corresponding officers attached at the central government.

Limitations of secondary data for the study area

Data missing for particular months/ weeks

The table below, used as an example to highlight problems with secondary data, shows data on respiratory communicable diseases from each of the seven health centres in the study area for 2004[9]. Data for some months of the year was absent for all PHCs/CHCc in the study area. The community health centre at Curchorem displays the worst reporting pattern with no data available for 2004.

Table C-C.2 Respiratory communicable disease data for the study area (Inpatient and Outpatient)

	Primary & Community Health Centres				Rural Medical Dispensaries		
	Cluster 1	Cluster 2	Cluster 3	Road corridor	Cluster 2	Cluster 2	Cluster 3
	Bicholim	Sanquelim	Sanguem	Curchorem	Surla	Pale	Dabal
Jan.	8	4	45	*	200	161	63
Feb.	2	5	60	*	78	*	92
March	68	8	18	*	109	122	160
April	*	31	*	*	88	102	79
May	5	54	11	*	90	50	216
June	226	*	15	*	73	91	162
July	361	*	15	*	157	119	82
Aug	279	Not available	*	*	89	88	148
Sept.	*	3	33	*	37	51	113

* Not reported

Interestingly, looking at the same table above, in some months we see that rural medical dispensaries which serve a much smaller population (average of five to six thousand) show higher reporting of respiratory communicable diseases compared to PHCs and CHCs, which serve population ranging between 45,000 to 90,000.

The lack of reporting/ data is not limited to only the mining areas or study area but is a common problem across the state. Of the 62 health care institutions (excluding sub-centres) across the state that are supposed to submit data monthly to the DHS, roughly 40 to 45 institutions actually submit data each month. Thus, a significant number of cases both in the study area and across the state remain unaccounted for.

No data from several peripheral health care institutions

Satellite sub-centres have weekly consultation hours with a doctor. Often this data is not submitted by the sub-centres to the Primary Health Centres which means that vital grass-roots data is lost.

No reporting from private health centres

Private facilities provide data on mortality, TB and Cancer to the Directorate of Health

[9] At the time of data collection from the Health Intelligence Bureau data was only available for January to September 2004. During subsequent visits in 2006 the HIB was unable to provide data for the remaining months of 2004.

(DHS). Additionally, private facilities are expected to provide relevant data for national programmes such as the Integrated Disease Surveillance Programme. However, general morbidity data is not compiled by private institutions and forwarded to the DHS. Given that a large number of people in the study area have reported using private health facilities, the absence of this data means that a large number of cases are going unaccounted.

Disease codes not always recorded

Recording general morbidity data requires using disease codes as classified by the World Health Organisation's International Disease Classification 10. Disease codes are not always recorded making compilation and analysis of the data difficult.

Patients place of residence not recorded

Data that is gathered does not reflect the patients' address. Thus, patients with complex cases referred to district/state hospitals get recorded as cases from the region in which the hospital is located. As Goa is a small state and bus connectivity is relatively good, people often go to hospitals that are not in their area of residence. Thus, it is not possible so estimate the variation in health status across different regions.

Problems with data management

Interviews and discussions with medical officers and other staff at the PHCs and CHCs helped to identify some of the problems that are leading to poor data management.

- Lack of staff

Until some years ago a compiler/checker attached to the Directorate of Statistics was posted at each Primary Health Centre (PHC) /Community Health Centre (CHC). These compilers have been transferred out of the health services and the posts have remained vacant for several years. None of the 5 PHCs/ CHCs in the study area has a designated person to carry out this task. The DHS has trained multipurpose health workers, lady health workers and doctors for the task of data compiling and management. However, as several posts in the health centres are vacant the staff is overburdened with work and the task of data collection and compilation is passed on to others (pharmacists, lab technicians etc.) who are not trained for the job. This affects the quality of the data that is generated and explains why there is no data from health centres for some months.

- Lack of oversight

The data that is recorded and compiled needs to be monitor regularly. No person is assigned with the responsibility to check the quality of the data. There seems to be lack of checking or oversight to ensure compliance by health centres.

- Focus on national programmes

The focus of primary health care services is on preventive health care, which is largely implemented through the various national programmes. As the Directorate of Health is obliged to report progress and targets achieved for the national health programmes to the central government there is a lot of emphasis on recording data pertaining to these programmes. Additionally, communicable diseases are given a high priority (as they should be) but no importance is laid on recording morbidity cases other than these. Hence the

workers at the primary health care level lay more emphasis on the health programmes and when staff are pressed for time, the compilation of the data for the various national programmes takes precedence.

Additionally, interviews with health officers suggest that at monthly meetings held at each Primary/Community Health Centre and at the Directorate of Health Services[10] discussions tend to centre round meeting targets (such as vaccinations, family planning operations etc) for the various national health programmes or the outbreak of communicable diseases or epidemics. These forums are not used to discuss health status within particular regions, trends in morbidity, or to analyse data generated through the system. As there are no health programmes dedicated to respiratory illness other than the tuberculosis control health programme and respiratory track infection in the case of children, general respiratory health has not been given any priority in terms of analysis even in the mining areas where health professionals perceive a particular problem.

- Paper based system

Although the health policy is geared to have all data computerized by 2005 (National Health Policy 2002) this has not occurred completely. This may be true for some of the national health programmes wherein data is directly uploaded onto the web. In order to facilitate computerization, at the different levels i.e. PHC/CHC and the different secondary level care, computers are provided. However these health centres lack competent staff to work with computers as a result of which they still use a paper based system and much of the burden of computerising data remains at the DHS level. In the absence of digitized data, not much analysis of the data is possible. Further, the use of a paper based system is time consuming and thus resulted in belated analysis which may not serve its purpose.

- Lack of a feed back mechanism

There is no mechanism whereby comments on the quality of the data (completeness, format etc) or data analysis done at the state level is passed back down to the regional level health care institutions. At the monthly meetings held at the DHS and at the PHCs/CHCs there is some discussion and analysis of data related to national programmes in the presence of medical officers from all the relevant health care institutions. However, doctors and medical officers reported that general morbidity data is not generally discussed.

Issues emerging at a policy level

Aside from the deficiencies in the functioning of the data collection system that have emerged through observations and discussions with health care professionals, the system itself merits comment. Perhaps the one of the most serious problems regarding health data is that state doesn't perceive the need for analysis of morbidity data. The poor condition of state-level data is probably a reflection of the fact that the data generated currently seems to

[10] At the PHC/CHC level these meetings are attended by all the key health workers attached to the health centre, including multipurpose health workers from the satellite Sub-centres. At the Directorate of Health Services (DHS) these monthly meetings, referred to as the Monthly Conference, are attended by the Health Officers of from each of the PHCs/CHS, District hospitals, Chief Programme Officers of the various national health programmes, the Dy. Directors, Director and Statisticians of the DHS.

serve no purpose. If, in fact, the data was actually in use, then the problems with the data set would have been addressed.

Another important problem that emerges very starkly in this project is the failure of the state health system to explore the links between environmental stressors and health in the context of mining. Interviews with health workers in the study area reveal that they perceive respiratory illness to be high in the region and they also attribute the problem to high dust pollution related to mining. Yet, in terms of dealing with respiratory health problems in the region the health care system seems to favour curative care rather than a preventive approach which would require acknowledging environmental stressors and attempting to deal with them in conjunction with other government agencies.

Linked to these two problems is the fact that Goa does not have its own state health policy. While the Central Government has drawn up a central health policy to guide health care provision across the country, each state, including Goa, has its own unique health needs and health problems that cannot necessarily be addressed only through the national health programmes. There is a need for the state to respond to existent or emerging health issues and to do this sound data that reflects the health status of the community is necessary.

D Format for communicable diseases

This format is prescribed by the central Ministry of Health and Family Welfare.

Reported cases and deaths due to communicable diseases

Report on communicable diseases for the month of .....

Name of the institution.....month.....

Sn.	Illness								
		OPD		IPD (patients treated)		Total		Deaths (IPD only)	
		Male	Female	Male	Female	Male	Female	Male	Female
1	Acute diarrheal diseases (including gastroenteritis and cholera)								
2	Diphethria								
3	Acute poliomyleietis								
4	Tetanus other than neo-natal								
5	Neonatal tetanus								
6	Whooping cough								
7	Measels								
8	Acute respiratory infections including influenza and excluding pneumonia								
9	Pneumonia								
10	Entric fever								
11	Viral hepatitis								
12	Japanese encephalitis								
13	Meningoccal meningitis								
14	Rabies								
15	Syphilis								
16	Gonoroccoal infection								
17	Pulmonary tuberculosis								
18	All other diseases treated in the institution excluding the above mentioned diseases								
	TOTAL								

OPD: Out patient

IPD: In patient

Annexure C

E Format for non-communicable diseases (general morbidity) data

Please note that no format or guidelines are used when filling, column 2 where disease are noted.

Name of the Urban Health Centre / Primary Health Centre / Community Health Centre / Hospital/ Rural Medical Dispensary.....

Morbidity report for the month of ..... 2006.....

Indoor/Outdoor

Code number	Disease	Sex			Religion				AGE																Result			Died Remark
		M	F	Total	Hindu	Christian	Muslim	Other total	1	1.4	5.9	10.14	15.19	20.24	25.29	30.34	35.39	40.44	45.49	50.54	55.59	60.64	65.69	70+		Cured	Improved	Same conditions	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Annexure C

F Governance questionnaire

To be filled by the investigator

Name of the interviewer: _____

Cluster: _____ Taluka: _____ Village: _____ Ward_____

Date: _____/_____/_____

Start Time	End Time

House hold number / code _____

GENERAL QUESTIONS

1. Sex
   1) Male
   2) Female

2. Does anyone in your family work in a mine or do any mine related jobs like have/drive a truck, work on a barge etc...?
   1) Technicians, mine electricians, mine operator, mine contractor, mine supervisor, fitter
   2) Work in a mine as daily wage labourer
   3) Own a truck (mine related)
   4) Drive a truck (mine related)
   5) Work in a truck repair garage
   6) Working on a barge
   7) Retired mine worker
   8) Other (mine related work - specify) _____
   9) Does not do mine or mine related work

3. Now lets talk about the village you live in. How long have you lived in this village?
   1) Less than a year
   2) 1 to 2 years
   3) 2 to 5 years
   4) 5 to 10 years
   5) 10 years and more

4.
   A. For some years now the Gram Panchayats have been active in Goa. They are required to hold 4 Gram Sabhas a year. Are you aware of this?
      1) Yes
      2) No
      3) Don't Know

   B. Now let's talk about the Gram Sabha. How often do you attend the Gram Sabha? Regularly, sometimes, once/twice or never?
      1) Regularly
      2) Sometimes
      3) Once or twice (rarely)
      4) Never

   C. If, never, sometimes, rarely
      - Why don't you attend the GS regularly?

1) Not interested
2) The Panchayat is too far
3) The timings don't suit me
4) No point in going because I don't think it will make any difference
5) Someone else from the family usually goes
6) I don't like the atmosphere at the meetings
7) Women don't usually attend, only men go
8) We are not informed about the date
9) Other_____

5. When you have a problem or request or some issue on your mind regarding the village who do you think you should go to?
   1) Panchayat member
   2) MLA
   3) Political Party
   4) Social Leader
   5) Other (specify)_____

6. If you have any work at the panchayat, is it easy to meet your Panchayat members, are they generally available?
   1) Yes, generally available
   2) Not always available
   3) Difficult to get in touch with
   4) Never available
   5) I've never had the need to visit them

WATER SUPPLY QUESTIONS

7. We are doing a study on the water situation in the area. I would like to ask you about the water situation in your home. Do you face any shortage of water for **household use** during the year?
   A. No
   B. Yes - Mar to May (Summer) **(1)** severe **(2)** not too bad **(3)** no problem
   C. Yes – June to Sept (Monsoons) **(1)** severe **(2)** not too bad **(3)** no problem
   D. Yes – Oct to Feb (Winter) **(1)** severe **(2)** not too bad **(3)** no problem

8. Now I will ask you about the different sources of water you use for household purposes during different seasons in the year?

(Write 1= for Yes and 2= No in the relevant columns)

Source	A Mar- May (Summer)	B June-Sept (Monsoons)	C Oct-Feb (Winter)	D Check if used for drinking/cooking
1.Tap at home				
2.Public tap				
3.Well/tube well				
4. Tankers				
5. Stream				
6. Spring				

WELLS

9.

A. Are there wells in your wada?
   1) Yes
   2) No (If "no" then go to Q11)

B. Are the water levels in the wells okay in the different seasons?

9Bi	March-May	1) Yes ok	2) No, level has dropped	3) No, well is completely dry	4) Don't know
9Bii	June-Sept	1) Yes ok	2) No, level has dropped	3) No, well is completely dry	4) Don't know
9Biii	Oct-Feb	1) Yes ok	2) No, level has dropped	3) No, well is completely dry	4) Don't know

If the answer is "Yes ok" for all three seasons then go to Q11.

10.

A. What is do you think is the cause of the problem?
   1) Mining and related activities
   2) Seasonal changes
   3) Other (specify) _____
   4) Don't know

B. When did they start going dry or how long has it been since the water levels have fallen?
   1) Less than 5 years
   2) Between 5-10 years
   3) More than 10 years

If the respondent has a private tap (refer to Q. 8) then ask the questions in the flowing section

PRIVATE TAP SUPPLY

11. I will ask you about the water supply for private taps in the different seasons. How would you describe your tap water supply? Do you consider it regular (does it come everyday) or irregular?
   A. March-May (Summer) **(1)** Regular **(2)** Irregular **(3)** No water at all **(4)** Don't know
   B. June-Sept (Monsoons) **(1)** Regular **(2)** Irregular **(3)** No water at all **(4)** Don't know
   C. Oct-Feb (Winter) **(1)** Regular **(2)** Irregular **(3)** No water at all **(4)** Don't know

12. Is the timing of the tap water regular? (that means, does it come at the same time daily?)
   A. Mar-May (Summer) **(1)** Regular **(2)** Irregular **(3)** Don't know
   B. June-Sept (Monsoons) **(1)** Regular **(2)** Irregular **(3)** Don't know
   C. Oct-Feb(Winter) **(1)** Regular **(2)** Irregular **(3)** Don't know

13. Approximately what time does the water come? (multiple choices ok)
   1) Morning
   2) Afternoon
   3) Evening
   4) Night
   5) In the middle of the night
   6) No fixed time
   7) Don't know

14. How many hours a day is the supply?
    A. Mar - May _____
    B. June - Sept _____
    C. Oct - Feb _____

Write the appropriate number in the space provided
1. No water at all 4. 6-12 hr s
2. Less than 2 hours 5. 12-24 hrs
3. 2-5 hrs a day

15. Roughly how much are your monthly bills?
    1) Less than Rs.50
    2) Between Rs. 51 to 75
    3) Between Rs. 76 to 100
    4) Between Rs.100- 150
    5) More than Rs. 150

16. What do you feel about the charges?
    1) Expensive- it's a strain on our monthly budget
    2) Reasonable, I can afford it, but it is high

17. Are mining companies paying your water bills?
    1) Yes
    2) No

PUBLIC TAPS

18. Are there public taps in your village?
    1) Yes
    2) No
    3) Don't know

Go to Q. 23

If No/Don't know then go to Q. 23

If 'YES' and the respondent uses public taps as a source of water (see Q.11) then continue below.

19. How would you describe your water supply? Do you consider it regular (does it come everyday) or irregular?
    A. March-May (Summer) (1) Regular (2) Irregular (3) No water at all (4) Don't know
    B. June-Sept (Monsoons) (1) Regular (2) Irregular (3) No water at all (4) Don't know
    C. Oct-Feb(Winter) (1) Regular (2) Irregular (3) No water at all (4) Don't know

20. Is the timing regular?
    A. Mar-May (Summer) (1) Regular (2) Irregular (3) Don't know
    B. June-Sept (Monsoons) (1) Regular (2) Irregular (3) Don't know
    C. Oct-Feb (Winter) (1) Regular (2) Irregular (3) Don't know

21. Approximately what time does the water come? (Multiple choices ok)
    1) Morning
    2) Afternoon
    3) Evening
    4) Night
    5) In the middle of the night
    6) No fixed time

7) Don't know

22. How many hours a day is the supply?

A. Mar-May _____
B. June – Sept _____
C. Oct – Feb _____

Write the appropriate number in the space provided

1. No water at all
2. Less than 2 hours
3. 2-5 hrs a day
4. 6-12 hr s
5. 12-24hrs

Go to directly to Q.28

23. **If NO,** Have there never been public taps in your ward, or have they been recently removed?

1) The taps have been removed recently **(Go to Q. 27)**
2) There have never been any public taps.
3) Don't know
4) Not applicable

Go to Q.31

IF PUBLIC TAPS WERE REMOVED

24. Did you use the public taps before?

1) Yes
2) No

25.

A. Before removing the taps were you informed?
1) YES
2) NO
3) Don't know
4) Don't remember
5) Not applicable

B. If yes, by whom?
1) Panchayat
2) PWD
3) Don't know
4) Other (specify) _____
5) Not applicable

C. Was your opinion sought?
1) YES
2) NO
3) Don't know
4) Don't remember
5) Not applicable

26. So when the public taps were removed, were you greatly inconvenienced, slightly inconvenienced, or was it no problem at all?

1) Greatly inconvenienced
2) Slightly inconvenienced
3) It didn't make a difference/ no problem at all

27. Did you get (or have you applied for) a private tap after the public taps were removed?
1) Yes
2) No, did not apply
3) No, had a private tap since before public tap was removed
4) Don't know

TANKERS

28. Do you receive water supplied through tankers?
A. NO **(Go to Q. 32)**
B. Yes Mar – May (Summer) **(1)** Daily **(2)** Alternate days **(3)** Only when needed **(4)** No
C. Yes June – Sept (Monsoons) **(1)** Daily **(2)** Alternate days **(3)** Only when needed **(4)** No
D. Yes Oct – Feb (Winter) **(1)** Daily **(2)** Alternate days **(3)** Only when needed **(4)** No

29.
A. Do the tankers come regularly?
1) YES
2) NO
3) Don't know

B. Do the tankers come at the same time everyday?
1) YES
2) NO
3) Don't know

30. How long ago did you start getting tanker water?
1) Less than 5 years
2) Between 5-10 years
3) More than 10 years

31. Do you know who pays for the tankers? (Multiple choices ok)
1) Panchayat
2) Mining Company
3) PWD
4) Other (specify)...
5) Don't know

32. What do you consider good water supply? (Multiple responses ok)

PEOPLE'S RESPONSES
This section is to be answered ONLY by those respondents who have said they have water supply problems.

33. If you have a water supply problem whom do you complain to or contact?
1) Panchayat/ Panchayat member
2) PWD
3) MLA
4) NGO
5) MP
6) Mamlatdar
7) Mining company
8) Others_____
9) No one

Annexure C

(Use each of the questions from Q. 34 to Q. 37 to fill in the details for each of the agents the respondent has contacted above)

34.

A. Complained or made a request to_____ (write the name of the appropriate agent and the corresponding no. (1-9) from Q. 33 above)

B. When did you complain/ make a request?

1) Within the last six months
2) Within the last one year
3) Within the last two years
4) Within the last 5 years
5) More than 5 years

C. What was the complaint about?

1) Irregular tap supply (i.e. not every day)
2) Erratic timings for tap water
3) Not enough tap water
4) Demand for taps in the village
5) Public tap leaking
6) Problem with pipes (leaking, broken, clogged etc.)
7) Dropping well water levels/wells going dry
8) Application for a free private tap connection
9) Erratic/irregular tanker supply
10) Other

D. Did the person you contacted show any interest/concern in solving the problem?

1) They showed a lot of interest/concern in solving the problem
2) They seemed moderately interested in solving the problem.
3) They didn't seem to care- showed no interest or concern.
4) Don't know

E. Did the situation improve?

1) YES - Improved slightly
2) YES – but only temporarily
3) YES – improved for good
4) Didn't improve
5) Solution is still being worked on

F. If the situation improved (slightly or temporarily or for good) then in how fast did the situation change/ how soon were your demands met?

1) Within a month
2) Within three months
3) Within six months
4) Within one year
5) More than one year

35.

A. Complained or made a request to_____ (write the name of the appropriate agent and the corresponding no. (1-9) from Q. 33 above)

B. When did you complain/ make a request?
1) Within the last six months
2) Within the last one year
3) Within the last two years
4) Within the last 5 years
5) More than 5 years

C. What was the complaint about?
1) Irregular tap supply (i.e. not every day)
2) Erratic timings for tap water
3) Not enough tap water
4) Demand for taps in the village
5) Public tap leaking
6) Problem with pipes (leaking, broken, clogged etc.)
7) Dropping well water levels/wells going dry
8) Application for a free private tap connection
9) Erratic/irregular tanker supply
10) Other

D. Did the **person you contacted** show any interest/concern in solving the problem?
1) They showed a lot of interest/concern in solving the problem
2) They seemed moderately interested in solving the problem.
3) They didn't seem to care- showed no interest or concern.
4) Don't know

E. Did the situation improve?
1) YES - Improved slightly
2) YES – but only temporarily
3) YES – improved for good
4) Didn't improve
5) Solution is still being worked on

F. If the situation improved (slightly or temporarily or for good) then in how fast did the situation change/ how soon were your demands met?
1) Within a month
2) Within three months
3) Within six months
4) Within one year
5) More than one year

Annexure C

36.

A. Made a request or complained to_____ (write the name of the appropriate agent and the corresponding no. (1-9) from Q. 33 above)

B. When did you complain/ make a request?
   1) Within the last six months
   2) Within the last one year
   3) Within the last two years
   4) Within the last 5 years

C. What was the complaint / request about?
   1) Irregular or erratic tap supply (i.e. not every day, not at the same time)
   2) Not enough tap water
   3) Demand for taps in the ward
   4) Application for a free private tap connection
   5) Dropping well water levels/wells going dry
   6) Erratic/irregular tanker supply
   7) Demand for more tankers
   8) Demand for sump, water tank, bore well etc.
   9) Request to company to pay tap water bills
   10) Others (Specify)_____

D. What was the attitude of the person you contacted?
   1) They showed a lot of interest in solving the problem.
   2) They seemed moderately interested in solving the problem.
   3) They didn't seem to care.
   4) Don't know

E. Did the situation improve?
   1) YES-Improved slightly
   2) YES – but only temporarily
   3) YES – improved for good
   4) Didn't improve
   5) Solution is still being worked on

F. If the situation improved (slightly or temporarily or for good) then in how long did the situation to change/ how soon were your demands met?
   1) Within a month
   2) Within three months
   3) Within six months
   4) Within one year
   5) More than one year

37.

A. Made a request or complained to_____ **(write the name of the appropriate agent and the corresponding no. (1-9) from Q. 33 above)**

B. When did / make a request?
1) Within the last six months
2) Within the last one year
3) Within the last two years
4) Within the last 5 years

C. What was the complaint / request about?
1) Irregular or erratic tap supply (i.e. not every day, not at the same time)
2) Not enough tap water
3) Demand for taps in the ward
4) Dropping well water levels/wells going dry
5) Application for a free private tap connection
6) Erratic/irregular tanker supply
7) Demand for more tankers
8) Demand for sump, water tank, bore well etc.
9) Request to company to pay tap water bills
10) Others (Specify)_____

D. What was the attitude of the person?
1) They showed a lot of interest in solving the problem.
2) They seemed interested but said they couldn't do anything about it.
3) They seemed moderately interested in solving the problem.
4) They didn't seem to care.
5) Don't know

E. Did the situation improve?
1) YES-Improved slightly
2) YES – but only temporarily
3) YES – improved for good
4) Didn't improve
5) Solution is still being worked on

F. If the situation improved (slightly or temporarily or for good) then in how fast did the situation change/ how soon were your demands met?
1) Within a month
2) Within three months
3) Within six months
4) Within one year
5) More than one year

Annexure C

OTHER FORUMS

38. Have water problems/ demands been discussed in the gram sabha?
1) Never
2) Once or twice
3) Sometimes
4) Regularly
5) Don't know

39.

A. Have you or anyone in your family taken up a water issue or discussed the water problem in any other group eg. Gram kriti samite, mahila mandal, SHG...
1) Yes, Gram kriti samitee
2) Yes, Mahila Mandal
3) Yes, SHG
4) Yes, Other_____
5) Don't know
6) No

→ **Go to Q. No. 40**

B. If yes, did the discussion lead to any action?
1) Yes, the group took some action
2) No, the group didn't take any action
3) I don't know
4) Not applicable

→ **Go to Q. No. 40**

C. If action **was** taken: Did the situation improve/ were demands met?
1) YES-Improved slightly
2) YES – but only temporarily
3) YES – improved for good
4) NO
5) Not applicable

D. Are there any women in this group/samiti?
1) Yes
2) No
3) Don't know

MORCHA/DHARNA

A. Have you or anyone in your family participated in a morcha/ dharna about water related problems?
1) YES
2) NO
3) Don't know
4) Don't remember

→ If "**No/Don't Know/Don't' remember**" then skip section and go to **Q. No. 41**

B. If yes, to whom did you take the morcha?
1) Panchayat
2) PWD
3) MLA
4) Mining company
5) MP
6) Mamlatdar
7) Other (specify)_____

C. What was the morcha about?
   1) Irregular or erratic tap supply (i.e. not every day, not at the same time)
   2) Not enough tap water
   3) Demand for taps in the ward
   4) Dropping well water levels
   5) Dry wells
   6) Erratic/irregular tanker supply
   7) Demand for more tankers
   8) Demand for sump, water tank, bore well etc.
   9) Request to company to pay tap water bills
   10) Others (Specify)_____

D. Did the situation improve?
   1) YES-Improved slightly
   2) YES – but only temporarily
   3) YES – improved for good
   4) Didn't improve
   5) Solution is still being worked on

40. Based on your (or anyone else in your family) interactions with the panchayat what do you feel is the role of the panchayat in solving your water problems? Do you feel your Panchayat- can solve water problems in this ward- do they have the ability? And does the panchayat want to solve it? Why?

Similarly, can the PWD solve your water problems? And do they want to?

Agency	(i) CAN solve the problem			(ii) WANT to solve the problem			Why Not? (if applicable)
	YES	NO	Don't know	YES	NO	Don't Know	
41 A Panchayat							
41 B PWD							

41. Why do you think your water problem has not yet been solved?
1) Village politics
2) Corruption in the government
3) Party politics
4) The problem will persist as long as mining continues
5) There are no solutions
6) There is no unity amongst the villagers
7) Nobody listens to us
8) Other_____

42. In areas where there are water problems we've heard that women cannot take up jobs or go out because they need to be around when the water comes. Is this the case in your home?
1) YES
2) NO- this is not a problem
3) NO– there are alternative sources of water
4) NO- there are others at home to help fill the water

AIR QUALITY QUESTIONS

43.

A. Do you think dust is a problem in your ward?
   1) Yes (Go to Q. 45)
   2) No
   3) Unwilling to talk about it

B. In the past was dust a problem for your ward?
   1) Yes
   2) No (Terminate Section)
   3) Unwilling to talk about it

44. How much of a problem is (was) the dust – no problem, somewhat of a problem, a major problem...?
   1) A problem for others in the ward, but doesn't affect us
   2) Somewhat of a problem
   3) A major problem
   4) Unwilling to talk about it

45. What is (was) causing the dust? (multiple choices ok)
   1) Movement of mining trucks through the village
   2) Mine pit located close by
   3) Screening plant close by
   4) Loading/unloading point close by
   5) Ore-stored nearby
   6) Railway yard close by
   7) Other (specify) _____
   8) Don't know

46. Since how long has the problem existed?/For how long was dust a problem? (no. of years)
   1) 0 to 5 years
   2) 5 to 10 years
   3) 10- to 15 years
   4) Over 15 years

PEOPLE'S RESPONSES

47. Have you or anyone in your family ever complained about the dust problem to any of the following listed below? (Multiple choices ok)
   1) Panchayat (Panch/Sarpanch)
   2) Gram Kruti Samiti/other village or ward level forum
   3) Mining Co.
   4) MLA
   5) Minister
   6) Mamlatdar
   7) Collector
   8) Other (specify) _____
   9) No one (Go to Q. 57)

Use each of the questions from Q. 49 to Q. 56 to fill in the details for each of the agents the respondent has contacted above

48.

A. Made a request or complained to_____ (write the name of the appropriate agent and the corresponding number (1-8) from Q. 48 above)

B. How much interest/concern did the agent show to address the problem?
1) Great interest/concern
2) Some amount of interest/concern
3) Not much interest/concern
4) No interest/concern at all
5) Don't know
6) Not applicable

C. To what extend did it solve the problem?
1) Completely
2) To some extent
3) Temporarily solved
4) Not solved
5) They are in the process of solving it
6) Don't know
7) Not applicable

49.

A. Made a request or complained to_____ (write the name of the appropriate agent and the corresponding number (1-8) from Q. 48 above)

B. How much interest/concern did the agent show to address the problem?
1) Great interest/concern
2) Some amount of interest/concern
3) Not much interest/concern
4) No interest/concern at all
5) Don't know
6) Not applicable

C. To what extend did it solve the problem?
1) Completely
2) To some extent
3) Temporarily solved
4) Not solved
5) They are in the process of solving it
6) Don't know
7) Not applicable

50.

A. Made a request or complained to_____ (write the name of the appropriate agent and the corresponding number (1-8) from Q. 48 above)

B. How much interest/concern did the agent show to address the problem?
1) Great interest/concern
2) Some amount of interest/concern
3) Not much interest/concern
4) No interest/concern at all
5) Don't know
6) Not applicable

C. To what extend did it solve the problem?
1) Completely
2) To some extent
3) Temporarily solved
4) Not solved
5) They are in the process of solving it
6) Don't know
7) Not applicable

51.

A. Made a request or complained to_____ **(write the name of the appropriate agent and the corresponding number (1-8) from Q. 48 above)**

B. How much interest/concern did the agent show to address the problem?
1) Great interest/concern
2) Some amount of interest/concern
3) Not much interest/concern
4) No interest/concern at all
5) Don't know
6) Not applicable

C. To what extend did it solve the problem?
1) Completely
2) To some extent
3) Temporarily solved
4) Not solved
5) They are in the process of solving it
6) Don't know
7) Not applicable

52.

A. Made a request or complained to_____ **(write the name of the appropriate agent and the corresponding number (1-8) from Q. 48 above)**

B. How much interest/concern did the agent show to address the problem?
1) Great interest/concern
2) Some amount of interest/concern
3) Not much interest/concern
4) No interest/concern at all
5) Don't know
6) Not applicable

C. To what extend did it solve the problem?
1) Completely
2) To some extent
3) Temporarily solved
4) Not solved
5) They are in the process of solving it
6) Don't know
7) Not applicable

53.

A. Made a request or complained to_____ (write the name of the appropriate agent and the corresponding number (1-8) from Q. 48 above)

B. How much interest/concern did the agent show to address the problem?
   1) Great interest/concern
   2) Some amount of interest/concern
   3) Not much interest/concern
   4) No interest/concern at all
   5) Don't know
   6) Not applicable

C. To what extend did it solve the problem?
   1) Completely
   2) To some extent
   3) Temporarily solved
   4) Not solved
   5) They are in the process of solving it
   6) Don't know
   7) Not applicable

54.

A. Made a request or complained to_____ (write the name of the appropriate agent and the corresponding number (1-8) from Q. 48 above)

B. How much interest/concern did the agent show to address the problem?
   1) Great interest/concern
   2) Some amount of interest/concern
   3) Not much interest/concern
   4) No interest/concern at all
   5) Don't know
   6) Not applicable

C. To what extend did it solve the problem?
   1) Completely
   2) To some extent
   3) Temporarily solved
   4) Not solved
   5) They are in the process of solving it
   6) Don't know
   7) Not applicable

55.

A. Made a request or complained to_____ **(write the name of the appropriate agent and the corresponding number (1-8) from Q. 48 above)**

B. How much interest/concern did the agent show to address the problem?
1) Great interest/concern
2) Some amount of interest/concern
3) Not much interest/concern
4) No interest/concern at all
5) Don't know
6) Not applicable

C. To what extend did it solve the problem?
1) Completely
2) To some extent
3) Temporarily solved
4) Not solved
5) They are in the process of solving it
6) Don't know
7) Not applicable

56.

A. Do you think the panchayat should take up the dust problem for the residents?
1) YES
2) NO
3) NO OPINION

B. Why should they take / not take it up?
1) They are incapable/have no intention of solving it
2) They are corrupt/they are on the side of the mining companies
3) They should as it is their duty/responsibility
4) They are our elected representatives, and therefore they have to
5) Since it concerns people's (health) problems, they have to/must take it up
6) They are the closest (government) agency to us so they should take it up
7) They have the power to force the companies to listen/solve the problem
8) Don't know
9) Other (specify) _____
10) Not applicable

57. **GRAM SABHA**

A. How often is the issue of dust pollution discussed at the gram sabha?
1) Regularly
2) Sometimes
3) Once or twice
4) Never
5) Don't know

Go to Q. 59

B. After the issue was brought up at the gram sabha how much interest/ concern did the panchayat take to address the problem?
1) Great interest/concern
2) Some amount of interest/concern
3) Not much interest/concern
4) No interest/concern at all

5) Don't know
6) Not applicable

C. To what extend did it solve the problem?
1) Completely
2) To some extent
3) Temporarily solved
4) Not solved
5) Don't know
6) Not applicable

58. **MORCHAS/DHARNAS**

A. Have you or your ward members participated in any morcha/dharna protesting against the dust problem?
1) YES
2) NO
3) Don't Know

} if N/DK then Go to **Q. No. 60**

B. Who did you take the morcha to?
1) Mining Co.
2) Panchayat
3) MLA
4) Mamlatdar
5) Collector
6) Police
7) Don't know
8) Other (specify)_____

C. How much interest/ concern did the agent you took the morcha to show to address the problem?
1) Great interest/concern
2) Some amount of interest/concern
3) Not much interest/concern
4) No interest/concern at all
5) Don't know
6) Not applicable

D. To what extend did it solve the problem?
1) Completely
2) To some extent/solved partially
3) Temporarily solved
4) Not solved
5) Don't know
6) Not applicable

E. Why do you think the morcha did not help solve the problem? (Multiple choices ok)
1) Solutions provided were temporary
2) Mining co. paid off the leaders/others in the community
3) The community did not follow-up after the morcha
4) There is no true will to solve the problem
5) The problem will persist as long as mining will continue
6) There are no solutions
7) There is no unity amongst the villagers
8) Nobody listens to us

9) Other (specify) _____
10) Don't know

STOP! CHECK: If respondent has reported **currently having dust pollution** problems **then carry on below with Q. 60** else go to **Q. 61**

59. Now I will name a few agencies/people to you, can you tell me who in your mind, CAN solve the dust problem and who you think really WANT solve the problem?

Agency	(i) CAN solve the problem			(ii) WANT to solve the problem			Why Not? (if applicable)
	YES	NO	Don't know	YES	NO	Don't know	
A. Panchayat							
B. MLA							
C. Mamlatdar							
D. Police/RTO							
E. Truck owners/drivers							
F. Local citizens/groups like Gram Kruti Samitis							
G. State Pollution Control Board							
H. Mining companies							
I. Other (specify)							

60. Why do you think there has been no solution to the dust problem yet?
Now directly go to Q.63

ASK Q.62 ONLY IF RESPONDENT SAYS DUST POLLUTION WAS A PROBLEM IN THE PAST.

61. Who/What do you think had a major role to play in solving the problem or getting it to lessen? (multiple choices are ok)
    1) Panchayat
    2) Residents of the ward/village, Gram Kruti Samiti etc...
    3) Mining-companies
    4) Your MLA
    5) The Collector
    6) The Mamlatdar
    7) SPCB
    8) Mining has stopped/lessened in the area
    9) Other (specify) _____
    10) Don't know

62. Do you know that the Pollution Control Board in Goa is responsible to solve air pollution problems?
    1) YES
    2) NO

63. When you approach the Panchayat for some work are you expected to pay a bribe for the Sarpanch's/ Pancha's/ Panchayat Secretary's help? For example, if you want to have a private tap installed, an NOC or a house number issued, do you need to pay a bribe to the Panchayat members?
    1) Never
    2) Sometimes, depends on the person
    3) Sometimes, depends on the nature of the work
    4) Almost always
    5) Don't know, never had to approach the Panchayat for work
    6) Unwilling to talk about it

64. How do they ask for bribes?
    1) They don't, it is common knowledge that we have to pay/It is understood that we have to pay
    2) They overtly ask
    3) They make some indication and we understand they want us to

HEALTH SECTION

65. How regularly you or your family avail the following health care facilities?

A.	Govt. Sub Centre	(1) Regularly (2) Sometimes (3) Rarely (4) Never
B.	Govt. R M.D	(1) Regularly (2) Sometimes (3) Rarely (4) Never
C.	Private Dispensary / clinic	(1) Regularly (2) Sometimes (3) Rarely (4) Never
D.	Mobile dispensary / Help age	(1) Regularly (2) Sometimes (3) Rarely (4) Never

66. If government sub centers or Rural Medical Dispensary are rarely or never visited: Why have you not visited the health Sub centre or RMD regularly? (multiple choices ok)

1) Not close by
2) Not aware that this facility is available
3) Doctor is not available daily
4) These centres are open only during working hours
5) Need to wait for a long time
6) Medication is not available
7) Unsatisfied with the treatment
8) No faith/trust treatment
9) Indifferent or rude attitude of the doctor/staff
10) Any other (Specify)_____

67. If Private dispensaries or clinics are used:
Is this dispensary / clinic provided by the mining company?

1) Yes
2) No
3) Don't Know

68. If answered "regularly" "sometimes" or "rarely" to Q. 69 above, then:
How would you rate your experience/ interaction with the above health care facilities in terms of the following criteria?

	CRITERIA	(i) GOVERNMENT HEALTH SERVICES-SC and RMDs RATINGS				(ii) PRIVATE DISPENSARIES / CLINICS RATINGS			
a)	Availability of doctor/ paramedical staff	1. Not available	2. Sometimes available	3. Available	4. Don't know	1. Not available	2. Sometimes available	3. Available	4. Don't know
b)	Availability of medicines	1. Not available	2. Sometimes available	3. Available	4. Don't know				
c)	Cost of treatment	1. Expensive/ not affordable	2. Reasonable	3. Free	4. Don't know	1. Expensive/ not affordable	2. Reasonable	3. Free	4. Don't know
d)	Faith and trust in the treatment	1. No faith	2 Some amount of faith	3. Great deal of faith	4. Don't know	1. No faith	2 Some amount of faith	3. Great deal of faith	4. Don't know
e)	Attitude of doctor / paramedical staff	1. Rude	2. Indifferent	3. Caring	4. Don't know	1. Rude	2. Indifferent	3. Caring	4. Don't know
f)	Appointments and waiting time	1. Long waiting time	2. Fairly reasonable waiting time	3. No waiting time	4. Don't know	1. Long waiting time	2. Fairly reasonable waiting time	3. No waiting time	4. Don't know
g)	Distance to health care	1. Very far	2. Reasonable distance	3. Close by	4. Don't know	1. Very far	2. Reasonable distance	3. Close by	4. Don't know

69. How regularly you or your family avail the following health care facilities?
   A. Govt. Primary Health Care (PHC) **(1)** Regularly **(2)** Sometimes **(3)** Rarely **(4)** Never
   B. Govt. Community Health Care (CHC) **(1)** Regularly **(2)** Sometimes **(3)** Rarely **(4)** Never
   C. Private Nursing homes **(1)** Regularly **(2)** Sometimes **(3)** Rarely **(4)** Never
   D. Private hospitals **(1)** Regularly **(2)** Sometimes **(3)** Rarely **(4)** Never

70. If government facilities such as PHCs, CHCs are rarely or never visited:
Why have you not visited the primary or secondary health care center
   1) Not close by
   2) Not aware that this facility is available
   3) Facilities are not available/ working
   4) Doctor is not available
   5) These centers are open only during working hours
   6) Need to wait for a long time
   7) Medicines are not available
   8) No faith in their treatment
   9) Indifferent or rude attitude of the doctor/staff
   10) Any other (Specify)_____

71. If Private hospitals or nursing homes are used:
Who pays for the medical expenditure?
   1) Self
   2) Mining company
   3) Part mining company – part self
   4) Employer (if other than mining company)
   5) Part employer (if other than mining company) – part self
   6) Through insurance bought by self
   7) Through insurance bought by employer

Annexure C

72. If answered "regularly" "sometimes" or "rarely" to Q 72, then:
How would you rate your interactions with the above health care facilities in terms of the following criteria?

	CRITERIA	GOVERNMENT HEALTH SERVICES-PHC/ CHC RATINGS				PRIVATE HOSPITALS / NURSING HOMES RATINGS			
a)	Availability of doctor/ paramedical staff	1. Not available	2. Sometimes available	3. Available	4. Don't know	1. Not available	2. Sometimes available	3. Available	4. Don't know
b)	Availability of medicines	1. Not available	2. Sometimes available	3. Available	4. Don't know				
c)	Availability of treatment facilities (like x-ray, blood-testing, operation theatres etc.) and Emergency facilities (like ambulances, 24-hr doctors etc)	1. Not available	2. Sometimes available	3. Available	4. Don't know	1. Not available	2. Sometimes available	3. Available	4. Don't know
d)	Attitude of doctor / paramedical staff	1. Rude	2. Indifferent	3. Caring	4. Don't know	1. Rude	2. Indifferent	3. Caring	4. Don't know
e)	Cost of treatment	1. Expensive/ not affordable	2. Reasonable	3. Free	4. Don't know	1. Expensive/ not affordable	2. Reasonable	3. Free	4. Don't know
f)	Faith and trust in the treatment	1. No faith	2 Some amount of faith	3. Great deal of faith	4. Don't know	1. No faith	2 Some amount of faith	3. Great deal of faith	4. Don't know
g)	Appointments and waiting time	1. Long waiting time	2. Fairly reasonable waiting time	3. No waiting time	4. Don't know	1. Long waiting time	2. Fairly reasonable waiting time	3. No waiting time	4. Don't know
h)	Distance to health care	1. Very far	2. Reasonable distance	3. Close by	4. Don't know	1. Very far	2. Reasonable distance	3. Close by	4. Don't know

Now I will ask you last few questions about you and your family:

73. Age_____

74. What is your level of education?
1) No schooling
2) Primary (up to 4th STD)
3) Secondary (up to 10th STD)
4) Higher secondary (up to 12th STD)
5) Bachelors degree (B.A, B.Sc., B.Com, B.Tech etc...)
6) Masters degree (M.A, M.Sc., M.Com, M.Tech etc...)
7) Vocational training (electrician, typing, tailoring, mechanics etc...)

75. Approximately what is your **monthly** income?
1) Rs. 1000 - Rs.2000
2) Rs. 2000 - Rs.3000
3) Rs. 3000 - Rs.4000
4) Rs. 4000 – Rs. 6000
5) Rs. 6000 – Rs. 8000
6) Rs. 8000 – Rs. 10,000
7) More than Rs. 10,000

I really appreciate your taking the time to answer my questions, Thank-you very much.

"Dev Borem Koru!"

Annexure D

Contents

Revised QoL tool 77
Environment and Social Performance Indicators (Companies) 85
Environment and Social Performance Indicators (Government) 89

Annexure D

QOL INDICATORS (VERSION III) - REVISED

Economic

Employment & Work Conditions	
What is your main occupation?	
Do you have a regular paid employment (> 6 m/yr)?	1. Yes 2.No
Do you feel that your job is secure?	1. Yes 2.No 3. Don't know
Satisfaction with job	1. VDS 2. DS 3. N 4. S 5. VS
Income	
What is the average income of your household? (Per month)	
Satisfaction with income	1. VDS 2. DS 3. N 4. S 5. VS
Opportunity Space	
Do you have access to any traditional livelihood opportunities?	1. Yes 2.No
Would you/your family be able to meet unforseen expenses of up to Rs.5000 within a week? (From bank, kin, etc)	1. Yes 2.No
Do you have opportunities/access to learn new skills / develop old skills?	1. Yes 2.No
Do you have access to employment training/ programmes/ new job opportunities?	1. Yes 2.No
How satisfied are you with the opportunities that you have?	1. VDS 2. DS 3. N 4. S 5. VS
Nutrition	
How much do you/your family spend on food per month?	
Do you and your family have sufficient food to eat in a day?	1. Yes always 2.No 3. Sometimes
Satisfaction with nutritional levels	1. VDS 2. DS 3. N 4. S 5. VS
Basic Amenities	
What is the main cooking fuel used?	1. Gas 2. Kerosene 3. Fuel wood 4. Twigs 5. Dung 6. Any other
If firewood/twigs collected from nearby areas, distance travelled:	1. Within 100m 2. Within 500m 3. Within 500m –1 km 4. >1 km 5. > Fuel wood bought

Annexure D

What is the kind of sanitation facility available to you?	1. No toilet 2. Inside home 3. Outside home 4. Public toilet 5. Any other
Do you have easy availability of water for drinking/other domestic purposes?	1. Within house 2. Within 100 m 3. Within 200 m 4. Within 1 km 5. > 1 km
How satisfied are you with availability of these amenities?	1. VDS 2. DS 3. N 4. S 5. VS
Infrastructure	
Do you have access to communication services (postal, email, telegraph)?	1. Yes 2.No
Do you have electricity in your home?	1. Yes 2.No
Do you avail of water distributed by public services?	1. Yes 2.No
Do you have a telephone access at home?	1. Yes 2.No
Do you use the public transport system?	1. Yes 2.No
Do you have sufficient places to water and pasture livestock?	1. Yes 2.No
Do you use any of the facilities offered by the government? (Starting new ventures/ subsidies, support, loan)	1. Yes 2.No
How satisfied are you with the above services?	1. VDS 2. DS 3. N 4. S 5. VS
Assets	
What is the ownership status of your place of residence/house?	1. Own 2. Rent 3. others _____
How much land do you own? (in ha)	
Do you have any livestock? (number per type)	1. Yes 2.No
Satisfaction with these assets	1. VDS 2. DS 3. N 4. S 5. VS

Annexure D

Social

Family & Community Life	
Do you have the support of the extended family and/or friends?	1. Yes always 2.No 3. Sometimes
Do you have a good family life?	1. Yes most of time 2.No 3. Sometimes
Do you have good relations with relatives?	1. Yes 2.No 3. Sometimes
Satisfaction with family	1. VDS 2. DS 3. N 4. S 5. VS
Do you have a community life?	1. Yes 2.No 3. Sometimes
Are you able to express solidarity with others?	1. Yes 2.No
Satisfaction with community life	1. VDS 2. DS 3. N 4. S 5. VS
Choices regarding marriage and reproduction	
Did/Do you have a choice in matters regarding marriage?	1. Yes 2.No 3. Restricted 4. N.A.
Did /Do you have a choice regarding the number and spacing of Children?	1. Yes 2.No 3. Restricted 4. N.A.
How satisfied are you with the degree of freedom?	1. VDS 2. DS 3. N 4. S 5. VS
Education	
What educational qualification or level have you achieved?	a. Primary level b. Secondary level c. Post secondary level d. Vocational training
How satisfied are you with your level of education attained?	1. VDS 2. DS 3. N 4. S 5. VS
Do your children have the opportunity to go to school /higher education?	1. Yes 2.No
How satisfied are you with the education they have received?	1. VDS 2. DS 3. N 4. S 5. VS

What kind of access to information do you have?	Public- library Private- Newspaper, Television Radio c. Any other
Social Security	
Do you have access to social security benefits ?(e.g. free or subsidized medical support, child support, education support from the State, pension)	1. Yes 2.No 3. Do not know
Satisfaction with social security	1. VDS 2. DS 3. N 4. S 5. VS
Do you and/or your family have access to any sports facilities? (Playground, fields etc)	1. Yes 2.No
Do you feel physically safe in the village? (i.e. free from crime or the threat of crime) (√ Below)	1. All the time 2. Most of the time 3. Some times 4. Never
Are there any vices such as alcoholism, prostitution, drug abuse etc within your family?	1. Yes 2.No 3. A little
Conflict Resolution	
What are the mechanisms you use or support to resolve conflict? (Courts, police, *panchayat*)	
Do you support the use of traditional ways to prevent & resolve conflict (family, other informal groups, religious heads)	1.Yes 2. No
How satisfied are you with the conflict resolution mechanisms that you have access to?	1. VDS 2. DS 3. N 4. S 5. VS

Political

Participation	
Do you participate in decision making/ planning/ implementing in any or all of the below? (√ below)	a. Household level b. Village/municipal level
Do you participate in local politics?	1. Yes 2.No
Are you involved in monitoring critical issues in your village?	1. Yes 2.No

How satisfied are you with your participation?	1. VDS 2. DS 3. N 4. S 5. VS
How are you engaged in civic life? (√ Below)	a. By voting b. By being part of a cooperative society c. Making demands of public services d. By running for a public position / standing for election
How satisfied are you with your engagement?	1. VDS 2. DS 3. N 4. S 5. VS
Governance	
Do you find that there is enforcement of rules by government bodies?	1. Yes 2.No 3. Do not know
Do you find the following in your dealings with Government? (√ as appropriate)	a. Honesty b. Stability c. Accountability d. None of the above ❑
How satisfied are you with governance in Goa ?	1. VDS 2. DS 3. N 4. S 5. VS
Political & Legal Rights	
Do you feel/ think you know your legal rights?	1. Yes 2.No 3.Sometimes
Do you have access to legal aid if you need it?	1. Yes 2.No
Can you afford legal aid if you were to need it?	1. Yes 2.No
Are you aware of your political rights? (Right to free speech, view)	1. Yes 2.No 3. Some of them
Satisfaction with political and legal situation	1. VDS 2. DS 3. N 4. S 5. VS

Biomedical

Health Facilities	
Are there any primary health care facilities (public/private) nearby area?	1. Yes 2.No
Is there a family welfare centre/maternity clinics/child care centre nearby area?	1. Yes 2.No
Are there any night/emergency healthcare facilities in the nearby area?	1. Yes 2.No

Are there any dental clinics in the nearby area?	1. Yes 2.No
Is there any alternative or traditional medical system available in the nearby area?	1. Yes 2.No
Do you find western/modern medicines that you need easily available here?	1. Yes 2.No
Do you or your family get the immunisation programmes available easily?	1. Yes 2.No 3. NA
Satisfaction with health facilities available	1. VDS 2. DS 3. N 4. S 5. VS
How would you describe the quality of health care facilities? (e.g. to have facilities with qualified nurses, regular physician visits, sufficient and clean equipment)	1. V Bad 2. Bad 3. Fair 4. Good 5. V. Good
Economic Ability to Maintain Health	
Can you afford any of the medical treatment/immunisation programmes not supported by the government?	1. Yes 2.No 3. NA
Do you have medical insurance (Public or private) facility?	1. Yes 2.No
Do you have medical coverage facility?	1. Yes 2.No
Satisfaction with economic ability to maintain health	1. VDS 2. DS 3. N 4. S 5. VS
Health Status	
Do you depend on western/modern medicines (in order to be able to undertake your daily activities?)	1. Yes 2.No
Are you free from physical illness/ mental illness (depression, mental stress, anxiety etc.)?	1. Yes 2.No
Is your family free from any physical or mental disabilities?	1. Yes 2.No
Is your family free from any chronic illness?	1. Yes 2.No
Do you get enough sleep / rest to have sufficient stamina to carry out your daily activities?	1. Yes 2.No
Do you have good appetite and digestion?	1. Yes 2.No
Do you have good reproductive health / fertility?	1. Yes 2.No 3. NA
Do you have sufficient vigour and stamina to carry out your daily activities?	1. Never 2. Some of the time 3. Most of the time 4. All of the time
Type of frequent or recurring illness in the family	
How satisfied are you with your general health status?	1. VDS 2. DS 3. N 4. S 5. VS
Does your work involve health and safety risks?	1. Yes 2.No

	3. NA
How satisfied are you with the health and safety situation you are faced with at your work place?	1. VDS 2. DS 3. N 4. S 5. VS
Are you able to experience emotional compatibility with those important to you?	1. Yes 2.No
Do you have Self – confidence/ Self respect	1. Yes 2.No 3. Sometimes
How satisfied are you with your emotional life?	1. VDS 2. DS 3. N 4. S 5. VS

Environmental

How would you describe the air quality that you are faced with in your daily life?	1. V Bad 2. Bad 3. Fair 4. Good 5. V. Good
Are you free from noise (loud & constant)?	1. Yes 2.No
Is the place you live in free from man made vibrations?	1. Yes 2.No
Satisfaction with present level of noise and vibrations	1. VDS 2. DS 3. N 4. S 5. VS
How would you describe the water quality for drinking that you are faced with in your daily life?	1. V Bad 2. Bad 3. Fair 4. Good 5. V. Good
How would you describe the water quality for other purposes in your daily life?	1. V Bad 2. Bad 3. Fair 4. Good 5. V. Good
Do you think that water source for drinking/ other domestic purposes available sufficiently?	1. Yes always 2. Sometimes 3. Uncertain
Satisfaction with water availability	1. VDS 2. DS 3. N 4. S 5. VS
Satisfaction with water quality	1. VDS 2. DS 3. N 4. S 5. VS
How would you describe the changes in the natural landscape around you?	1. No change 2. V Bad 3. Bad 4. Fair 5. Good 6. V. Good
How would you describe the quality of the land you have to cultivate and maintain animals?	1. V Bad 2. Bad 3. Fair 4. Good 5. V. Good
How would you describe the changes in the number or quantity of plants in your area over the last ten years?	1. No change 2. Decreasing amount 3. Increasing amount
How would you describe the changes in the number or quantity of animals in your area over the last ten years?	1. No change 2. Decreasing amount

	3. Increasing amount

Do you feel exposed to the occurrence of calamities like floods, droughts, landslides, etc?	1. Periodically in monsoons 2. Continuously 3. Rarely
Satisfaction with the overall quality of your physical environment	1. VDS 2. DS 3. N 4. S 5. VS
Is the place (you work/live) clean?	1. Yes 2.No
Is the place (you work/live) accident-free (vehicular)?	1. Yes 2.No
Are there any Open/Green spaces around the place of work?	1. Yes 2.No
Are there any Open/Green spaces around the place you live?	1. Yes 2.No
Satisfaction with the overall appearance of the surrounding landscape	1. VDS 2. DS 3. N 4. S 5. VS

Spiritual

What is the level of spirituality / religion in your life?	1. High 2.Medium 3. Low 4. None
Do you believe in customs and traditions/ rituals?	1. Yes 2.No 3.Somewhat
Are you involved in festivals and religious ceremonies?	1. Yes 2.No
Do you have strong personal beliefs?	1. Yes 2.No 3.Somewhat
Do you believe in a God?	1. Yes 2.No 3.Somewhat
Is there a place of worship close by?	1. Yes 2.No
How important for you to build new/renovate/painting of place of worship?	1. High 2. Medium 3. Low 4. None
How satisfied are you with your spiritual life?	1. VDS 2. DS 3. N 4. S 5. VS
How satisfied are you with the accessibility of places of worship?	1. VDS 2. DS 3. N 4. S 5. VS

Annexure D

INDICATORS FOR COMPANIES

No.	Indicator title	Indicates	Type	DPSIR	Unit
	Background				
	Reserves/Production (R/P) ratio	The life of mine	Primary	State	Years
	Units of ore produced annually	Potential environmental stress in the region	Proxy	Pressure	Tons/year
	Total workforce at mine site by gender and skill level	The profile of the workforce	Primary	State	Number/year
	Core issue: Environmental quality				
1A.i	Existence of policy on environmental quality management	Commitment to sustainable use and management of natural resources	Primary	Response	Yes/No & Policy document
1A.ii	Environmental standards certification	Good environmental management practices	Primary	Response	Yes/No & Name of standard
1A.iii	Instances of structural failure, per year	Potential pressure on environmental resources	Primary	Pressure	Number/year & Description
1A.iv	Environmental Impact Assessment (EIA) conducted	Commitment to sustainable environmental management and adherence to environmental regulations	Primary	Response	Yes/No
1.1A	*Sub-issue: Water quality and quantity*				
1.1A.i	Effluents discharged not meeting standards	Pressure on water resources in the region	Primary	Pressure	Cubic meters/year & Description
1.1A.ii	Monitoring of water quality at all points of exit from the mine	Attention to water quality leaving the lease area	Primary	Response	Number (stations/frequency) & Description/year
1.1A.iii	Water usage (ground and surface water) per year	Progress towards sustainable water use over time	Primary	Pressure	Cubic meters/ton/year
1.1A.iv	Recycling of tailings water	Commitment to sustainable water use	Primary	Response	Percentage/year
1.1A.v	Volume of ground water pumped out for mining operations	Pressure on groundwater resources in the local aquifer	Primary	Pressure	Cubic meters/year
1.1A.vi	Pit water put to productive use	Attention to sustainable water resource management and good environmental practice	Primary	Response	Percentage/year & Description
1.2 A	*Sub-issue: Air quality*				
1.2A.i	Ambient concentration of air pollutants in various locations within the mine lease area and buffer zone	Air quality within the lease area	Primary	State	µg/m3 (micrograms per cubic meter) & Description
1.2A.ii	Practices followed for transport and handling of ore	The level of pressure on air quality in the region	Primary	Pressure	Description/year
1.2A.iii	Public reporting & dissemination of air quality data	Commitment to maintaining transparency in terms of environmental outcomes	Primary	Response	Description/year

1.3 A	*Sub-issue: Land*				
1.3A.i	Annual land use plan for mining lease area	Efforts towards sustainable land use and management	Primary	Response	Plans/year
1.3A.ii	Ore to overburden ratio	Potential pressure on land resources	Proxy	Pressure	Ratio
1.3A.iii	Management of overburden dumps to ensure physical and chemical stability	Environmental management practices adopted by the company	Primary	Response	Description
1.3A.iv	Conservation of topsoil	Land management practices followed	Primary	Response	Percentage/year & Description
1.3A.v	Total agricultural/horticultural land area affected by mining per year	Extent to which land is impacted due to mining	Primary	Impact	Hectares/year
	Core issue: Land compensation				
2.A.i	Compensation for surface rights lost to lease	Fairness and adequacy of compensation paid for lost land	Primary	Response	Rupees/unit land & Description
2.A.ii	Provision for community rehabilitation and resettlement	Whether company has taken responsibility for rehabilitation and resettlement and adequacy of provisions	Primary	Response	Description
2.A.iii	Compensation for crop loss	Fairness and adequacy of compensation paid for crop loss	Primary	Response	Rupees/unit output or Rupees/unit land & Description
	Core issue: Mine closure				
3.1A	*Sub-issue: Socio-economic issues of closure*				
3.1A.i	Policy on socio-economic aspects of mine closure	Commitment to addressing socio-economic impacts of mine closure	Primary	Response	Policy document or description
3.1A.ii	Initiatives towards keeping the community informed regarding mine closure	Fulfillment of corporate social responsibility	Primary	Response	Description/year
3.1A.iii	Number of jobs terminated by mining company including outsourced jobs	The number of people estimated to be directly impacted by mine closure	Primary	Impact	Number/year
3.1A.iv	Workers receiving compensation	Concern for the welfare of workers	Primary	Response	Number & Description
3.1A.v	Financial support for job search and relocation for workers	The companies commitment to reducing socio-economic impacts of mine closure	Primary	Response	Rupees/worker

Annexure D

3.2A	*Sub-issue: Environmental issues of closure*				
3.2A.i	Policy on environmental aspects of mine closure	Commitment to address potential environmental impacts of mine closure	Primary	Response	Policy document
3.2A.ii	Plans for post closure land use	Consideration given to productive use of land resources after mine closure	Primary	Response	Description
3.2A.iii	Environmental rehabilitation/reclamation plan	Commitment to rehabilitating/reclaiming mine lease area and systematic approach to land rehabilitation /reclamation	Primary	Response	Yes/No & Plans
3.2A.iv	Financial provisions for environmental management during closure phase	Commitment to implementing the closure plans.and its commitment to sustainability	Primary	Response	Yes/No & Description
3.2A.v	Rehabilitation/ reclamation completed per year relative to closure phase plans	Timely fulfillment of rehabilitation/ reclamation responsibilities	Primary	Response	Description/year
	Core issue: Health				
4.1A	*Sub-issue: Health status*				
4.1A.i	Number of casualties and fatalities at the mine site	Occupational health impact of mining on workers	Primary	Impact	Number/year & Description
4.1A.ii	Alcoholism within the workforce	Psychological stress within the workforce	Proxy	Impact	Number/year
4.1A.iii	Illness associated with specific metallic mining detected amongst the workforce	Impact of mining on the health of the workforce	Primary	Impact	Number of cases/illness/year
4.2A	*Sub-issue: Health care*				
4.2A.i	Health care benefits provided to various categories of worker	Commitment to maintaining a healthy workforce	Primary	Response	Description
4.2A.ii	Policy on occupational health and safety of workers	Commitment towards occupational health and safety of workers	Primary	Response	Description
	Core issue: Participation				
5.1A	*Sub-issue: Opportunities for participation*				
5.1A.i	Community consultation meetings held per year	Company's effort to create opportunities for participation	Primary	Response	Number/year & Description
5.2A	*Sub-issue: Information availability and access*				
5.2A.i	Information regarding the company and mining projects in the public domain	The availability of information about the company and mining project in the public domain	Primary	Response	Description / year

Annexure D

	Core issue: Social and community relations				
6A.i	Existence of a Corporate Social Responsibility (CSR) policy	Company's commitment to fulfilling its social responsibility	Primary	Response	Yes/No & Policy document
6A.ii	Existence of a community relations (CR) officer	Importance given to community relations and issues	Primary	Response	Yes/No
6A.iii	Number of litigations/legal action initiated by the community/civil society against the company	Level of stress in community-company relations	Proxy	Impact	Number/year
6A.iv	Research into community perceptions of mining project	Concern for the welfare of the local community	Primary	Response	Yes/No & Description
6A.v	Initiatives to develop and maintain a relationship with indigenous/tribal population	Concern for the welfare of marginalized groups	Primary	Response	Description/year
	Core issue: Labour and employment				
7A.i	Average wages paid to men and women within various categories of worker (skilled, semi-skilled and unskilled)	Commitment to gender equality and fairness when setting wage rates	Primary	State	Rupees/ category-men and Rupees/ category-women
7A.ii	Percentage of jobs outsourced through labour contractors	Percentage of workers potentially facing poor working terms and conditions	Proxy	Pressure	Percentage
7A.iii	Percentage of workers hired from local region (*taluka*)	Positive impact of mining on local community in terms of employment	Primary	Impact	Percentage/year
7A.iv	Number and description of legal actions against the company by workers/workers' unions	Company's relationship with workers	Proxy	State	Number & Description
7A.v	Existence of industrial relations policy	Concern for labour and companies' commitment to providing a healthy and positive work environment	Primary	Response	Description or policy document
7A.vi	Amount invested on training and capacity building	Company's commitment to enhancing skills of their own work force	Primary	Response	Rupees/worker/year & Description
	Core issue: Investment in the region				
8.1A	*Sub-issue: Investment in physical capital*				
8.1A.i	Annual investment in roads	Investment in physical capital in mining regions	Primary	Response	Rupees/ton/year
8.1A.ii	Annual investment in physical infrastructure (other than roads) in the region	Investment in physical capital in mining regions	Primary	Response	Rupees/ton/year
8.2A	*Sub-issue: Investment in human capital*				
8.2A.i	Annual investment in occupational/vocational training and capacity building / or children's education within the community	Investment in human capital in mining regions	Primary	Response	Rupees/ton/year & Description
8.2A.ii	Annual investment in community health	Investment in human capital in mining regions	Primary	Response	Rupees/ton/year & Description

Annexure D

INDICATORS FOR GOVERNMENT

No.	Indicator title	Indicates	Type	DPSIR	Unit
	Background				
	Total population of mining *talukas* and watersheds	The population that can be potentially impacted by mining	Proxy	Impact	Number
	Regional literacy rates	The socio-economic conditions of the population in the mining region	Primary	State	Percentage
	Mining contribution to State Domestic Product (SDP)	The relative importance of mining in the state economy	Primary	Impact	Percentage/year
	Total royalties received per year	The benefits of mining to the state exchequer	Primary	Impact	Rupees/year
	Total number of active mine sites in the state	Level or intensity of mining activity in the state	Primary	State	Number/year
	Quarterly average market price per ton of ore	The intensity at which mining will be carried out	Primary	Driver	Rupees/ton/quarte
	Total units of ore produced per year	The amount of non-renewable resources exhausted annually	Primary	Pressure	Tons/year
	Core issue: Environmental quality				
1.1B	*Sub-issue: Water quality and quantity*				
1.1B.i	Groundwater quality meeting drinking water standards	Groundwater quality in the mining area and its suitability for drinking purposes	Primary	State	Yes/No & Results
1.1B.ii	Monitoring water quality of surface water bodies receiving run-off or into which effluents are discharged	Responsible action and concern for local ecology and community health	Primary	Response	Yes/No & Description
1.1B.iii	Groundwater withdrawals as a percentage of recharge in mining micro-watersheds	The level of criticality of a particular micro-watershed	Primary	Pressure	Percentage
1.1B.iv	Number of wards dependent on tanker water for household use	Shortage of water within the community and the need for more sustainable alternative sources of water	Proxy	Impact	Number
1.2 B	*Sub-issue: Air quality*				
1.2B.i	Annual ambient concentration of air pollutants outside the mine lease area	Air quality outside the mine lease area	Primary	State	µg/m3 & Description
1.2B.ii	Enforcement of air quality standards	State's commitment to enforcing the law	Primary	Response	Number & Description
1.2B.iii	Initiatives to educate the local community regarding impacts of air pollution and averting measures	State's efforts to inform the community regarding the causes and impacts of air pollution on health.	Primary	Response	Description

Annexure D

1.3 B	*Sub-issue: Land*				
1.3B.i	New areas brought under mining leases	The pressure on land resources in the state	Primary	Pressure	Hectares/year
1.3B.ii	Soil quality in mining watersheds	The impact on soil quality due to mining	Primary	Impact	Description
1.3B.iii	Degradation of forests located in mining regions	The impact on forest cover	Primary	Impact	Hectares/year & Description
	Core issue: Land compensation				
2.B.i	Existence of state policy on resettlement and rehabilitation	The state's commitment to ensuring the welfare of people displaced by development projects	Primary	Response	Yes/No & Policy document
2.B.ii	Total number of people displaced by mining activities	Impact of mining on local community	Primary	Impact	Number/year
.B.iii	Number of households receiving compensation for crop loss	The number of agricultural households impacted by mining activities	Primary	Impact	Number/year
.B.iv	Instances of disaffection relating to compensation payments	Dissatisfaction with the terms of compensation	Proxy	Response	Number/year
	Core issue: Mine closure				
3.1B	*Sub-issue: Socio-economic issues of closure*				
3.1B.i	Regional economic development plan	State's efforts towards planned development	Primary	Response	Description
.1B.ii	Financial plan for maintenance of infrastructure	The state's foresight, responsibility and concern towards the community	Primary	Response	Description
3.1B.iii	Change in unemployment rate in mining region	The impact of closure on the economy	Primary	Impact	Percentage change
3.1B.iv	Net migration rate in the mining region	The availability of work in the region and the impact of closure on the local economy	Primary	Impact	Number/thousand population or description
1B.v	Worker to population ratio/ work participation rate	The population that is engaged in productive labour market	Primary	State	Percentage
3.2B	*Sub-issue: Environmental issues of closure*				
3.2B.i	Regional land use plan	Efforts towards land management	Primary	Response	Yes/No & Description
3.2B.ii	Procedures followed for monitoring of mines in final closure phase	The state's commitment to ensuring sound environmental management of mine closure	Primary	Response	Description
3.2B.iii	Provisions for long-term monitoring of decommissioned mines	The extent to which the government is prepared to take on long-term responsibility of decommissioned mine sites	Primary	Response	Plans

Annexure D

	Core issue: Health				
4.1B	*Sub-issue: Health status*				
4.1B.i	Hospitalization and doctors visits per thousand population per year for mining related illness	Possible health impacts on local community due to mining	Primary	Impact	Number of cases/year
4.1B.ii	Number of road traffic accidents related to trucking in the mining regions	The risk to health and life of the local community in mining regions	Proxy	Impact	Number/year
4.1B.iii	Life expectancy at birth of men and women in the mining regions	The community health in the mining region	Proxy	State	Years (male & female)
4.1B.iv	Hospitalization and doctors visits for enteric diseases per thousand population per year in the mining regions	Poor health status of the community due to poor living conditions and indicates poor access to basic amenities	Primary	Impact	Number of cases/year
4.2B	*Sub-issue: Health care*				
4.2B.i	Ratio of medical staff to population in the mining region	Availability of health services in the mining region	Primary	Response	Ratio
4.2B.ii	Ratio of health care centres to population in the mining region	Availability of health facilities in the mining region	Primary	Response	Ratio
4.2B.iii	Primary health care in mining regions meeting national health guidelines	Adequacy of primary health care services provided by the state in mining regions	Primary	Response	Yes/No
4.2B.iv	Health and safety surveys conducted at the mine sites	Efforts towards upholding health and safety standards	Primary	Response	Percentage
	Core issue: Participation				
5.1B	*Sub-issue: Opportunities for participation*				
5.1B.i	Holding of public hearings	State's commitment to providing forums for community participation	Proxy	Response	Number /year
5.2B	*Sub-issue: Information availability and access*				
5.2B.i	Advertisement of public hearings	State's effort to provide information about public hearings	Primary	Response	Number & Description
5.2B.ii	Availability of mining related legislation in local languages	State's effort to provide information related to mining legislation	Primary	State	Name of legislation/local language
	Core issue: Labour and employment				
7B.i	Grievance cases resolved per year	State's commitment to enforcing labour laws	Primary	Response	Number/year
7B.ii	Labour inspections conducted per year	State's vigilance and concern for labour welfare	Primary	Response	Percentage/year

Annexure D

	Core issue: Investment in the region				
8.1B	*Sub-issue: Investment in physical capital*				
8.1B.i	Households having basic amenities in the mining region	State's investment in physical capital in the mining regions	Proxy	Response	Number/year
8.2B	*Sub-issue: Investment in human capital*				
8.2B.i	Educational facilities available in the mining regions	State's investment in human capital	Proxy	Response	Description
8.2B.ii	Availability of vocational training in the mining region	State's investment in human capital	Proxy	Response	Description/year