IRON MINING IN GOA (INDIA)

An interdisciplinary study

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Glossary

Alloy: A substance having metallic properties, and composed of two or more chemical elements, of which at least one is a metal.

Amphibole: The name of an important group of generally dark-colored, inosilicate minerals, forming prism or needle like crystals ,composed of double chain SiO_4 tetrahedral, linked at the vertices and generally containing ions of iron and/or magnesium in their structures.

Biodiversity hotspot: areas with over 1,500 vascular plant species as endemics and currently retain 30% or less of the original vegetation.

Biotite: Common phyllosilicate mineral within the mica group.

Blasting: The violent effect of such an explosion. Consisting of a wave of increased atmospheric pressure followed immediately by a wave of decreased pressure.

Buffer zone: Area created to avert the effect of negative environmental or human influences, and to enhance the protection of a conservation area, often peripheral to it, inside or outside.

Crore: 10,000,000

Crushing: Size reduction into relatively coarse particles by stamps, crushers or rolls.

Dhangars: herding caste. In Goa are merely shepherds.

Dead rent: the rent fixed for mines without considering the fact whether the mine is profitable or not. It is mostly fixed in a mineral lease. This rent must be paid whether or not minerals are being extracted from the mines. Even though mining comes under the category of one of the most hazardous occupation and expectation of profit is limited, mining leases fix dead rents on mining sites.

Deciduous: t is typically used in reference to trees that lose their leaves seasonally.

Denudation: The long-term sum of processes that cause the wearing away of the earth's surface leading to a reduction in elevation and relief of landforms and landscapes.

Dolerite dyke: Dolerite is coarse grained variety of basalt, if present in the dorm of a dyke (discordant igneous body); it is called a dolerite dyke.

Dutch disease: the industrialization of an economy as a result of discovery of a natural resource, as that which occurred in Holland with the exploitation of North Sea Oil, which raised the value of the Dutch currency, making its exports uncompetitive and causing its industry to decline.

Dump: A pile or heap of ore or waste at a mine.

Estuary: The seaward end or the funnel-shaped tidal mouth of a river valley where fresh water comes into contact with seawater and where tidal effects are evident.

Facies: A term of wide application, referring to such aspects of rock units as rock type, mode of origin, composition, fossil content, or environment of deposition.

Friable: Said of a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder.

Gabbro: Refers to a large group of dark, coarse-grained, intrusive mafic igneous rocks chemically equivalent to basalt. The rocks are plutonic, formed when molten magma is trapped beneath the Earth's surface and cools into a crystalline mass.

Geosynclinals: A mobile down warping of the crust of the Earth, either elongate or basin like, measured in scores of kilometres, in which sedimentary and volcanic rocks accumulate to thicknesses of thousands of meters. A geosyncline may form in part of a tectonic cycle, in which orogeny follows. Recognition of the plate structure of the lithosphere has led to appreciation that nearly all geosynclinals phenomena are related to ocean opening and closing.

Gross Domestic Product: measures the total market value of all final goods and services produced within a country in one year.

Gneiss: Typical rock type formed by regional metamorphism, in which a sedimentary or igneous rock has been deeply buried and subjected to high temperatures and pressures.

Greywacke or greywacke: Old rock with a dark grey, firmly indurated, coarse-grained sandstone that consists of poorly sorted, angular to sub angular grains of quartz and feldspar, with a variety of dark rock and mineral fragments embedded in a compact clayey matrix having the general composition of slate and containing an abundance of very fine-grained elite, sericite, and chlorite minerals.

Khazan: land reclaimed from the riverside and full of the silt washed down their banks, built up laboriously over thousands of years of meticulous planning, with sluice-gates to regulate the flow of water in and out of them, bringing in a fresh supply of nutrients, with much of its loamy land lying below sea-level. This land is purportedly the most fertile in Goa, though threatened now with irreparable

Konkani: the coastal belt, hedged in between the Arabian Sea and the Western Ghats that stretches from the Tapi River in the north to the Chandragiri River in the south. It includes the states of Maharashtra, Goa and Karnataka. The Konkani, the official language of Goa, takes its name from that region where it was created.

Kulgar: conventional system of land development characteristic to Konkan and Goa, which consists in land terraced around the houses.

Lakh: 100,000

Lens: Pyrite, round or oval in plan and lenticular in section, ranging up to 0.6 to 0.9 m in thickness and several hundred feet in the greatest lateral dimension, which is found in coal beds. Sometimes called kidney sulphur.

Limestone: Sedimentary rock composed largely of the minerals calcite and aragonite, which are different crystal forms of calcium carbonate($CaCO_3$).

Lokayukta: an anti-corruption authority constituted at the state level, based on the Scandinavian's ombudsmen. It investigates allegations of corruption and mal-administration against public administration. The person appointed is usually a former High Court Chief Justice or former Supreme Court judge.

Mafic: Describe a silicate mineral or rock that is rich in magnesium and iron.

Mudflats: Also known as tidal flats are coastal wetlands that form when mud is deposited by tides or rivers.

Nullah or nallah: A term used in the desert regions of India for a sandy river bed or channel, or a small ravine or gully, which is normally dry except after a heavy rain.

Overburden: Designates material of any nature that overlies a deposit of useful ores.

Paddy: is a flooded parcel of arable land used for growing semiaquatic rice.

Panchayat: The smallest unit of elected local self-government, comprising of a cluster of villages. Representatives are elected from these villages and constitute the Panhayat.

Phyllite: Type of foliated metamorphic rock created from slate that is further metamorphosed so that very fine grained white mica achieves a preferred orientation. It is primarily composed of quartz, sericite mica, and chlorite.

Pit: Excavation to hold quantities of water and drilling fluids.

Protolith: The original, unmetamorphosed rock from which a given metamorphic rock is formed.

Quartzite: non-foliated metamorphic rock which was originally pure quartz sandstone.

Rift: A trough or valley formed by faulting. A narrow cleft, fissure, or other opening in rock made by cracking or splitting.

Saprolita: A soft, earthy, typically clay-rich, thoroughly decomposed rock, formed in place by chemical weathering of igneous, sedimentary, and metamorphic rocks. It often forms a layer or cover as much as 100 m thick, esp. in humid and tropical or subtropical climates; the colour is commonly some shade of red or brown, but it may be white or grey. Saprolite is characterized by preservation of structures that were present in the unweathered rock.

Schistosity: Mode of foliation that occurs in certain metamorphic. It reflects a considerable intensity of metamorphism.

Screening: Lump lime after forking or screening to remove the finer portion.

Settling pond: A pond, natural or artificial, for recovering the solids from washers.

Shield : It is generally a large area of exposed Precambrian crystalline igneous and high grade metamorphic rocks that form tectonically stable areas. In all cases, the age of these rocks is greater than 570 million years and sometimes dates back 2 to 3.5 billion years. They have been little affected by tectonic events following the end of the Precambrian Era, and are relatively flat regions where mountain building, faulting, and other tectonic processes are greatly diminished compared with the activity that occurs at the margins of the shields and the boundaries between tectonic plates.

Sintering: A heat treatment for agglomerating small particles to form larger particles, in case of ores and concentrates, it is accomplished by fusion of certain constituents.

Syntectonic: Said of a geologic process or event occurring during any kind of tectonic activity, or of a rock or feature so formed.

Tailing pond: Area closed at lower end by constraining wall or dam to which mill effluents are run effluent.

Taluka: An administrative unit comprising a number of villages. A number of talukas make up a district.

Tenor: The relative quantity or the percentage of ore-mineral or metal content in an ore body.

Tube well: A tube well is a type of water well with stainless steel tube or pipe is bored into an underground aquifer. The lower end is fitted with a strainer, and a pump at the top lifts water for irrigation.

Weathered layer: In seismic work, a zone extending from the surface to a limited depth, usually characterized by a low velocity of transmission, which abruptly changes to a higher velocity in the underlying bedrock.

Weathering: The destructive processes by which earthy and rocky materials on exposure to atmospheric agents at or near the Earth's surface are changed in colour, texture, composition, firmness, or form, with little or no transport of the loosened or altered material.

Escarpment: Steep slope or long cliff that occurs from erosion or faulting and separates two relatively level areas of differing elevations.

Orography: The study of the formation and relief of mountains, and can more broadly include hills, and any part of a region's elevated terrain.

List of abbreviations

BGL: Below Ground Level

BIF: Banded Iron Formation

BJP: Bharatiya Janata Party

CBA: Cost-Benefit Analysis

CEC: Central Empowered Committee

CG: Central Government

CGWB: Central Ground Water Board

CST: Central Sales Tax

DE: Domestic Extraction

DMC: Domestic Material Consumption

DRI: Direct Reduced Iron

EC: Environmental Clearances

EIA: Environmental Impact Assessment

GAISP: Green Accounting for Indian States Project

GDP: Gross State Product

GF: Goa Foundation

GMOEA: Goa Mineral Ore Export Association

GMPF: Goa Mining People's Front

GSI: Geological Survey of India

IRADE: Integrated Research and Action for Development

ISP: Integrated steel plants

LPCD: Litters per capita per day

LR: Lower respiratory

MASL: Meters Above Sea Level

MCM: Million Cubic Meters

MFG: Mineral Foundation of Goa

MHM: Million Hectare Meters

MJ: Mega joule

MLD: Million Litters Day

MOEF: Ministry of Environment and Forest

Mt: Million tons

MW: Megawatt

NCAER: National Council of Applied Economic Research

NGO: Non-Government Organization

NP: National Park

NPV: Net Present Value

NSB: Net Social Benefit

PA: Protected Area

PM_{10}: Particulate matter smaller than 10 microns

RCD: Respiratory Communicable Disease

RNCD: Respiratory Non-Communicable Disease

ROM: Run of mine

RSPM: Respirable Suspended Particulate Matter

S.C.: Scheduled Castes

SDR: Social Discount Rate

SPM: Suspended Particulate Matter

S.T.: Scheduled Tribes

TB: Tuberculosis

TERI: The Energy and Resources Institute

TJ: Terajoule

TOE: Tons of Oil Equivalents

TPY: Tonnes per Year

UR: Upper Respiratory

VAT: Value Added Tax

WGEEP: Western Ghats Ecology Expert Panel

WHC: World Heritage Centre

WLS: Wildlife Sanctuary

INTRODUCTION

On 5th October 2012, iron mining was banned by the Supreme Court of India in the little state of Goa. The former Portuguese colony is divided into a prosperous coastal strip with many tourist visitors, a plateau midland and a mountainous area, belonging to the biologically rich Western Ghats from where the Mandovi and Zuari rivers come down. The Western Ghats tropical evergreen rainforest, which is considered as one of 25 Biological Hotspots on the Earth, is the habitat of many floral and faunal species, which a high rate are endemic, such as the nearly 38% of the 4000 vascular plant species recorded in India.

The strength of Goa is to have the 62% of the total forest area under protection by one National Park and 6 Wildlife Sanctuaries, which almost conserve the entire part of the Western Ghats lying in the State. Moreover, other unique ecosystems, like mangroves, are found in the ecological mosaic of Goa, becoming an area of high biological value.

The major deposits of iron ore are found associated with volcano-sedimentary Banded Iron Formation of Precambrian age and subject to vast seasonal changes. In addition, the extensive laterization due to the Goa's position in the tropical moist climate originated the formation of iron ore deposits.

Goa which is one of the smallest State of India exports around 50% of the total iron ore exported from the whole country. Iron ore which comprises a share of 95% of total mining and quarrying sector in Goa is 100% oriented to exports with China as the main buyer. After the exploitation the iron ore is carried out by trucks from the open cast mines to the jetties where the ore is discharged on the barges. Tertiary sector dominates the economic structure of Goa, followed by the secondary and primary sector in the third place. Although mining and quarrying contribution to Goa's GDP is around 5%, accounting all direct and indirect activities connected to mining activity, this industry represents the second most important industry next to tourism. Sesa Goa which is the main iron ore producing company exports about 50% of Goan iron ore. The consequences of this huge extraction material rate from mining are different environmental impacts such as pollution, water contamination, overburden dumps or health problems. Codli is the main mine from Goa and provides half of the Sea Goa´s production with 7 million tons per year. Consequently it gives us a representative picture of the reality. This study has supplemented the economic accounts with an analysis of material flows.

Goa's population is about 1.5 million living in 3702 sq.km. The birth rate is low but there is much immigration into this State. The impacts caused by the iron mining are a source of social conflict. Nowadays the ban of iron mining originates a large discussion due to the different interests between the stakeholders of Goa.

The incompatibility between the environmental and mining interests designs the framework of stakeholder roles. The Goan context clearly identifies three main groups of interests. First of all, the mining lobby is the most powerful part that is able to influence the governance of the States. Secondly, the village people living nearby the mines are directly affected. At the same time, many people are totally dependent on that business. Finally, the State government is trying to deal between the opposite interests of the previous parts.

The current Chief Minister Manohar Parrikar is pressured by the mining leaseholders to restart the activity but he needs to please the electorate in order to ensure the following legislature.

Finally, after the closure of the mining activity, the Supreme Court asked the Central Empowered Committee (CEC) to reject the illegalities found on the Shah Commission Report published in March 2012. The results of CEC were presented on November 2012 contrasting the findings of the previous report and the field working done by the representative´s Committee. Therefore Goa is waiting for the verdict of the Supreme Court that might take place on 10th of July 2013.

Background

Goa has huge deposits of iron ore mineral despite being the smallest state of the Indian Union. Those geological resources have been mined since the origin of the Indus civilization. During the last century the mining industry has been the basis of Goa's economy before the European tourism came to the heavenly beaches. Even today it is considered one of the growth engines of Goa. Nevertheless, the Konkani environment and society is suffering the hazard effects of that mining business.

Despite the European discover of the presence of iron ore in Goa was a Dutch traveller (in the 16th century) it took centuries for the then Portuguese rulers to start the mining of iron ore in Goa. In fact, it was in 1947 when the exportations of the mineral began and rapidly became the main economic activity. Moreover, the mining lobby has been considered as the most powerful influent sector of the Goa contemporaneous history. That lobby has been able to control the state government in order to break the environmental and social law related to the mining management without any punishment.

Nevertheless, the immediate impact of excessive mining has been noticed by the majority of the village people. The reduction of the forest cover, the huge dumps, the dust mineral particles and the water pumping and contamination are some of the principal harmful mining effects which suffer the Goan environment. Such negative impacts are, therefore, directly noticed by the villager's health. In addition, the welfare of the rural areas is also disturbed by conflicts between different social groups, like the mining workers and truck drivers and the farmers and tribal population.

In fact, several studies have been reported, especially after the eighty's, which emphasises those impacts of the open-cast mining in the Goan Western Ghats region. Some of them are reported below, those ones which have had a major influence through the mining stakeholders.

In 1962 the National Council of Applied Economic Research (NCAER) prepared their first report for GMOEA titled *Techno Economic Survey of Goa, Daman and Diu - Contribution of Iron Ore to Economic Development of Goa* and in 2010 *A study of the contribution of Goan Iron ore Mining Industry*. One of the first approaches to the environmental dimensions was the *Effect of Mining on the Ecosystems of Sanguem, Bicholim, Sattari and Quepem Taluka, Goa*, written by the Dhempe College of Arts and Science, in 1987. Ten years later The Energy and Resources Institute (TERI) wrote, submitted by the government of Goa the *Area Wide Quality Management Plan (AEQM) for the Mining Belt of Goa*.

In the 21st century, the iron mining exploitation underwent and incredibly increment, directly caused by the growth of the Chinese giant's economy. In 2006, the TERI published another report called *Environmental/Social Performance Indicators (ESPIs) and Sustainability Markers in Minerals Development: Reporting Progress Towards Improved Health and Human Well-being, Phase III* which tries to identify the respiratory illness related to the suspended particulate matter and its health costs in the mining regions of Goa. In 2008, one of the most famous books about the mining, *Rich, Lands, Poor People: The Socio-Environmental Challenges of Mining in India*, was published by Chandra Bhushan (from the Centre for Science and Environment). It became so popular around the mining states because it deeply analyses the social effects of the ore extraction in that regions. Three years later, in 2011, the subsection about mining of the report of the WGEE (Western Ghats Ecology Expert) Panel stated that numerous mine leases were located in and around Wildlife Sanctuaries (WLS) and forested areas.

Notwithstanding this compilation, the Justice M. B. Shah Commission report about the *Illegal Mining in the State of Goa*, was published on March of 2012 and it became momentousness in the future of mining in Goa. After been approved by the Parliament, the government decided on September of the same year to temporally ban the mining activity in Goa in order to check all the illegalities stated by that report. Consequently, it was the main cause of the total closure ordered by the Supreme Court thanks to the Goa Foundation Writ Petition submitted immediately after the government's ban.

Justification

Unfortunately, the social and environmental problems due to the human uncontrolled development are often ignored by the powerful sectors. They will never yield their own immediate benefits (economical or even political) to the collective wellbeing of Nature and the population, as the reader would have already noticed, that has not been the case.

The sudden ban on iron mining in Goa has not allowed this report to include the properly evidences of the harmful impacts of that industry. However, that exceptional new scene gave the researches the chance to analyse its characteristics from the beginning.

Moreover, in such unexpected situation several environmental and social issues have come into the light. Hence, in order to be able to understand the whole social ecosystem matrix, it has been done a DPSIR scheme. Finally three scenarios have also been designed. Each one shows a feasible future for the Goan iron mining business and its effects on the society and environment of the state.

The sudden ban on iron mining in Goa has not allowed this report to include the properly evidences of the harmful impacts of that industry in such a small state. So, an exceptional new scene was given to the researchers to change the analysis of its characteristics from the beginning.

Moreover, the researchers found an opportunity to look through the causality of the current convulsed situation in a holistic view. It has been possible to understand the whole social ecosystem matrix but, above all, not to design feasible future scenarios without a properly independent criteria.

Research Questions and Hypotheses

Abiotic Environment

- ✓ Which traits in Goa geology explain the iron ore concentration?
- ✓ Which is the role of laterization?
- ✓ The quality of water, air and soil is decreased due to mining.
- ✓ The groundwater and surface availability of water are affected by mining.
- ✓ The mining waste is not treated.
- ✓ The iron total reserves will be exhausted/ depleted in 20 years.
- ✓ Agricultural productivity has decreased because of poor soil quality which is due to mining.

Biotic Environment

- ✓ Deforestation and biodiversity decrease are related directly on mining.
- ✓ Terrestrial and aquatic species of fauna and flora are affected by mining activity.
- ✓ Protected areas are affected by mining.

Social Features

- ✓ Respiratory health problems and water pollution related diseases have increased the last 10 years, as a result of pollution generated by mining activities (dust, leachate...). Specifically, in the villages which are closer to the mines.
- ✓ Poor people have more environmental awareness than rich people.
- ✓ The more inland, less population density. The population concentrates mainly on coastal regions.

Material Flow

- ✓ Domestic extraction in Goa is much higher than in India per capita terms.
- ✓ Mining companies consume a large portion of Goa´s energy.
- ✓ It would be possible to install a steel plant instead of exporting the iron ore, in terms of energy requirements.

Economic Feature

- ✓ Iron ore prices have been increased over the years.
- ✓ Most of the iron exported in Goa is sold to the Asian market.
- ✓ Environmental costs outweigh the social benefits of iron mining industry.
- ✓ Iron mining is considered as an opportunity to rise up their economy.
- ✓ Iron ore industry is the most important industry in Goa.
- ✓ Goa is the biggest exporter of iron ore in India.

Policy

- ✓ Portuguese influence is currently noticed on the Goan policy and management.
- ✓ There is no ecological planning in the state of Goa.
- ✓ Upper classes are not as aware as the village people about the environmental issues.
- ✓ Mine owners do not follow the environmental management measures.

- ✓ Goa Foundation actions are the unique cause of the mining ban.
- ✓ In Goa the mining activity is totally invulnerable.
- ✓ Central government is not concerned about the problems of Goa.
- ✓ State government is subjugated to the mine lobby.
- ✓ Judicial actions are crucial for environmental policy in India.

Scenarios

- ✓ How can the variables be integrated through the different scenarios?
- ✓ How has each variable changed due to the three scenarios?

General objectives

- ➲ Describe the iron mining conflict in Goa through different perspectives.
- ➲ Understand and analyse the social metabolism of Goa.
- ➲ Elaborate a diagnosis about material flow of iron mining companies which includes the extraction, transport and export of iron ore.
- ➲ Study the main stakeholders and their role within business of iron ore.
- ➲ Understand the importance of the mining sector in the economy of Goa.
- ➲ Analyse the harmful abiotic, biotic and social damages originated by mining activity.
- ➲ Identify the DPSIR of the mining activity in Goa.
- ➲ Study three different scenarios from the mining sector in Goa in order to provide information and encourage participation when decisions have to be made.

Specific objectives

1. Abiotic environment features:

- Describe abiotic environment context of the state.
- Elaborate the diagnosis about abiotic environment (geology, hydrogeology, climatology and topography).
- Identify and explain the main abiotic environment impacts due to mining activity.
- Explain the geological resources for the concentration of iron ores in Goa.

2. Biotic environment features:

- Elaborate the diagnosis about the flora and fauna biodiversity of Goan Ecozones.
- Describe the ecological value of Goa.
- Identify and explain the main pressures and impacts to flora and fauna populations by mining activity.

3. Social features:

- Study of the demography of Goa and the geographical distribution of the population.
- Study the profile of mine workers.
- Understanding the role of women inside and outside the mine.
- Study the negative effects of mining on society: health problems, effects on agriculture sector and effects on water available.
- Explain the opportunities provided by mining.

4. Material flow:

- Study of Domestic Extraction of Goa in a comparative context with Ecuador system.
- Explain the different stages and activities of Codli mine.
- Analize the energy, waste and water consumption of iron mining as well as the tranportation.
- Evaluate the greenhouse gas emissions.
- Calculate the possibility to set up a steel plan in Goa.

5. Economy features:

- Analyse the global iron ore market and India's place in it.
- Study an overview of the main iron ore producers in India.
- Explain the economic features related from Goa and concretely related to iron mining in Goa.
- Evaluate the cost benefit analysis of the mining activity in Goa.

6. Policy:

- Introduce the Goa environmental and mining evolution of town planning, law and policy.
- Explain the mining environmental management procedure.
- Describe and analyse the main stakeholders of mining.
- Analyse the casualty of mining ban.

7. DPSIR

- Asses and manage environmental problems due to iron mining activity.
- Summarize and link the issues related to mining using a flowchart.

8. SCENARIOS

- Exploring plausible futures to improve decision-making processes.
- Provide a picture of future alternatives states
- Increase the awareness about environmental problems due to mining activity.
- Evaluate Scenarios with a multi-criteria approach.

Methodology and data source

In order to achieve the goals of the project, the methodology used by the authors has been focused on three different strategies: literature review, field work and integration of the information.

The research started one year before arriving in Goa, it was also done during those days in India and then it continued from January until May 2013. This information was mainly extracted from surveys, articles and official pages on the internet.

The field work was undertaken in Goa (India) for three months from October 2012 to January 2013 and was focused on: interviews, data collection and visits to the interested areas.

During these months the field work was mainly based on interviews. The methodology used for the interviews were "Depth interviewing" which involves a small number of people, who are interviewed repeatedly and at length, in their language in a period of time. The first step was a meeting with Claude Alvares, the main activist against mining in Goa and the director of Goa Foundation (NGO) who provided us with all the contacts to start interviewing. The interviews were done in three groups of people. First, employees from the main mining firm (Sesa Goa) who were distinguished between autonomous workers and workers with a high charge. Second, activists who were fighting against iron mining and finally, people who were living close to the mines. During the interviews the six researchers were taking notes in a notebook with the aim of writing all this information together. Moreover, many inhabitants from Goa were randomly asked about mining conflicts in Goa.

The visits to interesting areas for the study were also important. The interesting areas of study were basically the mining areas; which includes Codli mine and a reforested are in Sanquelim both property of Sesa Goa, Mollem National Park and two towns close to mining areas called Cavorem and Sanvordem.

Finally, an accurate data collection was done due to the lack of information on the internet. Data collection was focused on the six chapters of the project. It means that the information was collected from different institutions in order to get information about Economy, Energy, Geology, Biology and Society.

It was difficult for the authors to follow a strict methodology during the field work due to the lack of implication from some stakeholders. However, it was possible to get enough knowledge to understand the mining conflict in Goa.

The integration of the information collected was done by two different methodologies: DPSIR and Scenarios.

Scheduled

PROJECT TASKS	February 2012	March	April	May	June	July	August	September	October	November	December	January 2013	February	March	April	May	June	July
Tutorials	Catalunya	Catalunya	Catalunya	Catalunya								Goa		Catalunya	Catalunya	Catalunya	Catalunya	
Bibliographic research	Catalunya	Catalunya	Catalunya	Catalunya				Catalunya	Goa	Goa	Goa	Goa / Catalunya	Catalunya	Catalunya				
Writing concept proposer		Catalunya	Catalunya															
Trip preparation					Catalunya	Catalunya	Catalunya	Catalunya	Catalunya									
Cultural immersion									Goa									
Contact NGO's										Goa	Goa							
Visit mining belt in Goa										Goa	Goa							
Depth interviewing										Goa	Goa	Goa						
Data analysis										Goa	Goa	Goa / Catalunya	Catalunya					
Writing project										Goa	Goa	Goa / Catalunya	Catalunya	Catalunya	Catalunya	Catalunya	Catalunya	
Speech preparation																		Catalunya
Delivery project																		Catalunya

In Catalunya

In Goa

CHAPTER I

ABIOTIC ENVIRONMENT

Author: Miriam Pablos Cascallar

Iron ore, Laterites, Monsoon, Western Ghats and Deposits of Iron Ore

INTRODUCTION

The abiotic (meaning not alive) environment includes all non-living physical and chemical factors and processes in an ecosystem which influence and affect living organisms.

Environmental factors such as habitat (ponds, lakes, oceans, deserts, mountains) or weather like temperature, cloud cover, rain, snow, hurricanes, sunlight, soil, water, and pollution are all important abiotic factors of an environment that affect life.

This section is divided in four subsections. These subsections are topography, climate, geology and hydrology of Goa.

- Topography comprises the study (description) of surface shape and features of the Earth. Specifically involves the recording of relief or terrain, the three-dimensional quality of the surface, and the identification of specific landforms (Hacettepe University. Department of Mining Engineering, 1996). In Goa, the relief is particularly relevant with mountains and coastal areas.

- Climate is the pattern of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods. The climate of a location is affected by its latitude, terrain, and altitude, as well as nearby water bodies and their currents (Hacettepe University. Department of Mining Engineering, 1996). Goa has, as most of India, a monsoon climate.

- Geology is the science comprising the study of solid Earth, the rocks of which it is composed, and the processes by which they change. Geology gives insight into the history of the Earth, as it provides the primary evidence for plate tectonics, the evolutionary history of life, and past climates (Hacettepe University. (Department of Mining Engineering, 1996)

Particularly, we ask ourselves why are there iron ore deposits in Goa, which are the geological reason, for this?

- Hydrology is the study of the movement, distribution, and quality of water, including the hydrologic cycle, water resources and environmental watershed sustainability (Hacettepe University. (Department of Mining Engineering, 1996). Goa has two main rivers, Zuari and Mandovi, and also estuaries rich in nutrients.

Therefore, for all abiotic aspects of the environment, the changing conditions require organisms to adapt. Small, subtle changes can also have important effects.

I. DIAGNOSIS

In order to study the abiotic environment an accurate research has done to understand the abiotic characteristics of Goa.

1. Topography

1.1. Location

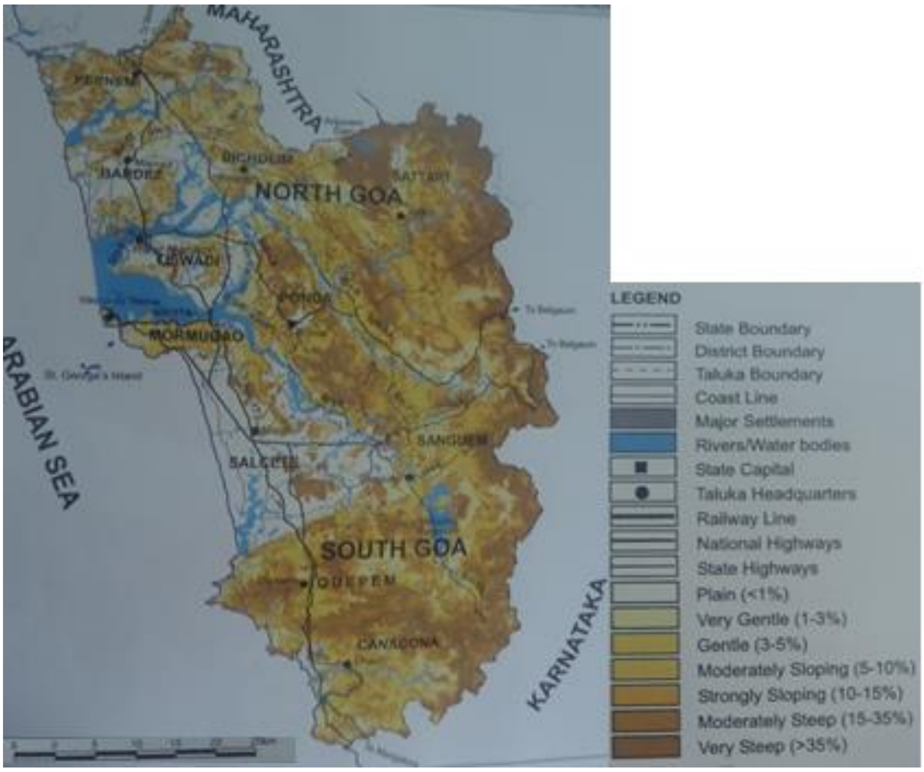
Goa is the second smallest state located on the west coast of India covering an area of 3702 sq kms and runs 105 km long and 65 km wide. Goa is located between latitudes 14º53'55'' N and 15º 47' 59'' N and longitudes 73º40'34'' E and 74º17'03'' E. The Arabian Sea marks the western boundary of the State. To the North and North East is the State of Maharashtra and to the East and South-East is bordered by Karnataka. The State if divided into two administrative districts namely North and South. All together there are 11 talukas, 189 Village Panchayats and 14 Municipalities. (Fernandes, 2009)

MAP 1.1: GEOGRAPHY OF GOA

Source: Fr. Nascimento Mascarenhas(2008)

1.2. Physiography

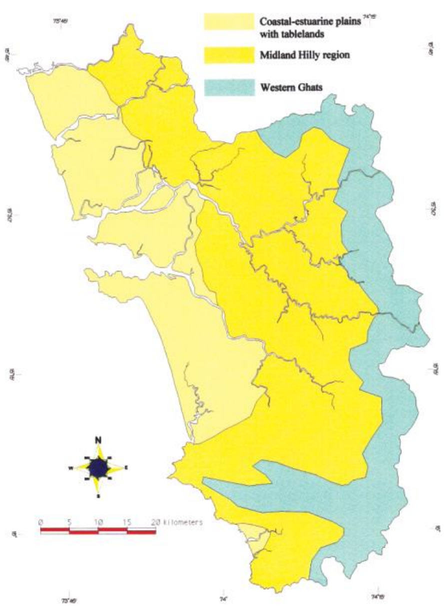
MAP 1.2: SLOPES OF GOA



Source: Central Pollution Control Board (2006)

Goa is essentially a rugged hilly and mountainous tract with narrow valleys and sandy linear plains along the coast. The terrain is undulating. The highest peak is Mamai Devi with 832 m height. The State is broader towards the North. (GSI, 2006)

MAP 1.3 : PHYSIOGRAPHIC DIVISIONS OF GOA



Source: O.A.Fernandes (2009)

Physiographically, the state can be classified into three types of terrain which grade from low lying coastal-estuarine plains to the West, undulating region in the central part, to the steep slopes of the Western Ghats on the eastern border of the state (Map 1.3). The three terrain types can be delineated roughly longitudinally, except in the far South of the State, where all three types seem to merge. (Fernandes, 2009)

The most visible or well-known part of Goa (especially by tourists) is the coastal belt which runs from north to south , while the least known is the Western Ghats region, which also runs from north to south in the hinterland. Sandwiched in between is the midland region. (Fernandes, 2009)

The coastal plain comprises the talukas of Bardez, Tiswadi, Mormugao and Salcete, which cover about 22% of the total geographical area. The intermediate or transitional sub mountainous region comprising the talukas of Pernem, Bicholim, Ponda and Quepem, with undulating uplands, covers about 35% of the area, whereas the interior hilly region of Sattari, Sanguem and Canacona talukas make up the remaining 43% of the area. (Fernandes, 2009)

Therefore, O.A Fernandes explains the each division on Natural Resources of Goa: A Geological Perspective book (2009):

- *The western coastal-estuarine plains with tablelands: This terrain consists of lowlying features like stretches of sandy beach, estuarine mudflats, khazan lands, mangroves, saltpans, fields and settlement areas. The estuarine plains extend to well over 10 to 12 km inland, particularly within the ower basins of the Mandovi and the Zuari, the two largest estuaries within the state. The plains are much wider and more prominent in North Goa; yet they do not stretch uniformly and are interrupted by low (less than 100 meters high) laterite topped plateaus (tablelands). In the far South of the state (the Quepem and Canacona coast) the coastal estuarine plains are much smaller, isolated and limited in extent. Here the terrain is often hilly and mountainous even near the Coast.*

- *The central undulating region (midlands): the "midland" portion neverless has significant ecological and cultural characteristics, often in sharp contrast to coastal Goa.*

  This region is made up of hills ranging from approximately 100 to 600 meters and is actually a transition between the lower coastal plain and plateau terrain and the steeper, higher terrain of the Western Ghats. This midland region is broader to the north, because the Western Ghats are situated much further inland in North Goa. The trend of the hills and the Ghats in North Goa is controlled by the structure (folding and schistosity) of the rock formations in the region. In North Goa the fold axis and schistosity of the rock formations is NW-SE (as are the Western Ghat ranges in North Goa). The coastline of Goa is also NW-SE and therefore the inland hill ranges remain almost parallel to the coast.

  As the coastline is almost North-South (NW-SE) the East-West trending hills and ridges encounter the sea at their Western ends. In this Southern region of Goa it is difficult to demarcate (with precision) midlands from Western Ghats because the transition from the rugged (hilly cliffs) coastline to mountain ridge tops is sharp.

- *The Western Ghats: The Sahyadris known as the Western Ghats. This hilly region has an area of about 600 sq km , consists of steeper and higher ranges (600 to 1000 meters high), and cover the Eastern and*

Southern portions of Goa. The crestline extends in an arc for about 125 km. The Western Ghats (Sahyadris) have a general NW-SE trend (except for the ranges in south Goa). In north Goa they are more than 40 km away from the sea. In the south however, the trend of the hills, which is related to the underlying rock structure, is almost East-West (WNW-ESE)."

1.2.1. The specific physiography of Western Ghats

TABLE 1.1: GEOGRAPHICAL ATTRIBUTES OF THE WESTERN GHATS

Attributes of the Western Ghats	
Northern limit	8°19′ 8″ - 21° 16′ 24″ (N)
Eastern limit	72° 56′ 24″ - 78° 19′ 40″ (E)
Total area	129037 sq km
End-to-end length	1490 km
Min width	48 km
Max width	210 km

Source: Ministry of environment and forests (2007)

Goa occupies a very small portion of the Western Ghats, these hill ranges run the western peninsula parallel to the west coast for about 1600 km and often hardly 40 km from the Arabian Sea .They start immediately south of the Tapti river, the northern most point being, the Kundaibari Pass in Dhule district of Maharashtra and ending near Kanyakumari barely 20 km from the sea in Tamil Nadu. (Paimohan, 2008)

The Western Ghats cover an area of approximately 129.000 km^2 with an average elevation of 900-1500m. Although the average heights of the Ghats is less than 1500 m, in the southern reaches it rises 2000 m and to exceptionally higher peaks of 2500 m and above. The average width of the mountain range is about 100 km. (Paimohan, 2008)

2. Climatology

Goa is grouped under Western Zone Agro-Climatic region of India. The state is situated well within the tropics. It has tropical maritime and monsoon type of climate influenced to a large extent by conditions in the Arabian Sea and orography. For this reason, the climate is humid throughout the year due to proximity of the seas. (Environmental Atlas of Goa, 2006)

The main feature of the Goan climate is the monsoon. There are four seasons corresponding to winter (December to February), summer or Pre-monsoon (March to May), monsoon (June to September) and post-monsoon (October and November). Goa experiences a dry period lasting six to eight months of the year, followed by the annual rainfall, which occurs over the remaining four months. During the two months preceding the beginning of the monsoon, the humidity increases. The average relative humidity is 70 – 90% (reaching the highest value during the monsoon). (Environmental Atlas of Goa, 2006)

2.1. Temperature

TABLE 1.2: MAXIMUM AND MINIMUM TEMPERATURES FOR PANAJI AND MORMUGAO TOWNS

	Mean		Highest		Lowest	
Year	**Maximum**	**Minimum**	**Temperature**	**Date**	**Temperature**	**Date**
Panaji						
2004	32.2	23.0	38.6	06/05/04	18.2	01/02/04
2005	31.9	22.9	38.7	15/03/05	16.6	18/12/05
2006	32.2	23.3	37.3	06/02/06	16.6	24/01/06
2009	32.3	22.0	39.2	21/02/09	19.0	6/01/09
Mormugao						
2004	31.9	24.3	38.4	07/05/04	20.4	01/02/04
2005	31.4	24.1	35.3	24/11/05	19.3	18/12/05
2006	31.7	24.4	36.4	12/02/06	19.5	24/01/06
2009	31.5	25.3	36.2	2/11/09	20.8	01/01/09

Source: Goa Observatory (Panaji- Goa) and own elaboration (2009)

Generally, the temperature varying between 20 º and 35 º C. Temperature variations through the seasons are slight. Along the coast, the maximum temperature recorded rarely goes beyond 38 ºC.

The average minimum temperature in the winter is to the tune of about 18ºC and reaches to a maximum of 36ºC in summer. Being located in the proximity of Arabian Sea the diurnal variation of temperature is very small.

Winter in Goa is marked by nights of around 21°C and days of around 28°C. Mainly, the month of May is the hottest, seeing day temperatures of over 35°C.

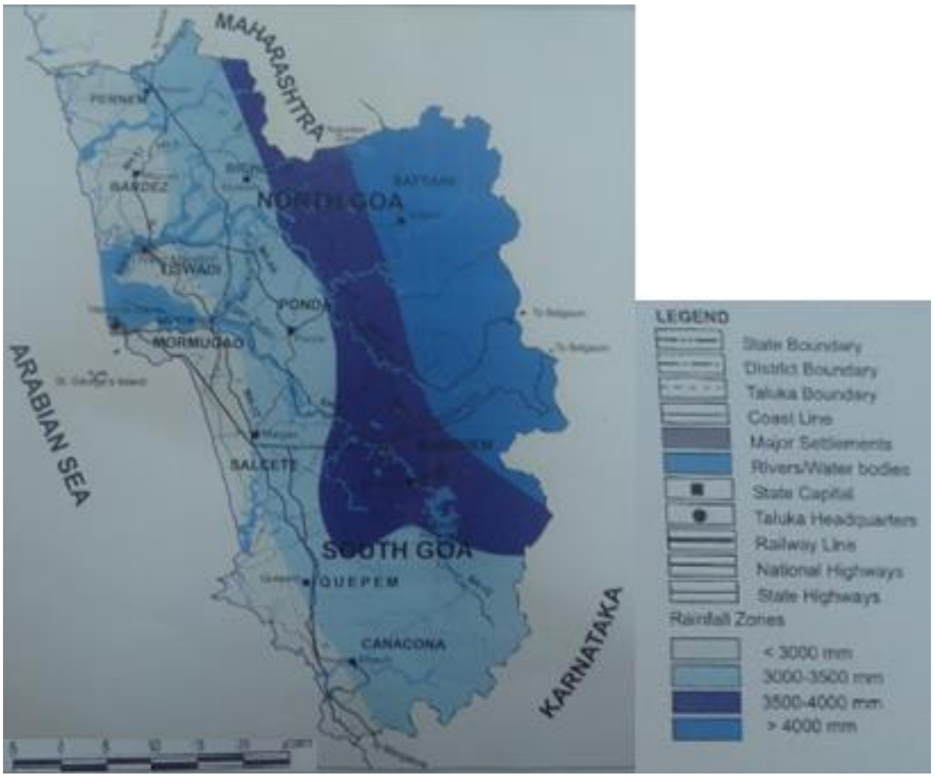
The temperature gradient is mostly related to increase in altitudes. The influence of the decreasing temperature with increased altitude is explicit only in those regions of the Ghats where the altitude is sufficiently high from 700 or 800 m upwards. Generally, the mean temperature of the coldest months ranges from 23 ºC at sea level to 11^{o}C at 2,400 m. However, for the same elevation, the temperature may vary considerably from one place to another, depending on exposure or slope. (Environmental Atlas of Goa, 2006)

2.1.1. Temperature variation due to mine

The effects of temperature around the mine are conditioned by the initial stages of drilling and excavation of soil in the mining process. For example, when carrying out the excavation, the heat into the soil is released outside and consequently, the outside temperature can increase up to 40 ° C. (Belap, 2012)

2.2. Rainfall

MAP 1.4: RAINFALL



Source: Directorate of Agriculture, Goa (2006)

Annual rainfall varies from 3000mm to 5000mm and the average number of rainy days is 110. In Catalonia, the annual rainfall is 400 or 500 mm, so in Goa rainfall is much higher. During the monsoon, 250 cm to 300 of rain is normal in Goa. Most of the rainfall is from the South West Monsoons between the months of June to September. (Environmental Atlas of Goa, 2006)

Western region receives more rainfall mainly due to the orographic effect of the mountains on the monsoon laden winds. Coastal area receives average annual rainfall of 2500 mm to 3500 mm. The precipitation increases to as much as 5000 mm as we move eastwards towards the high ranges of the Western Ghats. The eastern slopes of the Ghats are much drier than the Western face. (Environmental Atlas of Goa, 2006)

2.2.1. The Rainfall Gradients

According to The Western Ghats book (2008), Paimohan explains the two rainfall gradients of Western Ghats:

"*The* ***west-east*** *rainfall gradient is determined by the effect of Ghats' escarpment. The reliefs of the Ghats act as a barrier to the eastward movement of the cloud masses brought by the summer monsoon rain-bearing winds of the south-west monsoon.*

These masses bring amount of rainfall over the western slopes of the Ghats. Overall the western slopes receive 2,000 to 7,500 mm of rainfall. The rainfall decreases rapidly to < 800mm towards the interior plateau of the east within a distance of 7 to 60 km, from 7,500 mm to 4,000 mm within 15 km, and to 2,000 mm within 50 km. Further north towards the latitude of Goa, the decrease is even more drastic: 25 km after the summit of the Ghats the rainfall is insufficient to support the evergreen formations.

In some cases, edaphic compensation (especially better moisture holding capacity of soils) enables the maintenance of evergreen formations even when the rainfall is somewhat lower.

The ***south-north*** *gradient is an important feature of the Western Ghats where they form more or less continuous chain of hills with a latitudinal extent of almost 12 degrees. The monsoon, the very pulse of India, adds yet another dimension: the duration of the dry season gradually increases from two months in the southern parts of the Ghats to over eight months north of Mumbai. This gradient is determined by the arrival and withdrawal of the summer monsoon.*

The monsoon generally arrives towards the end of May at the southern tip of India, in the first week of June at Thiruvananthapuram (south of Kerala), five days later it reaches Karwar (below Goa), in another five days it has already crossed Mumbai and by middle of June it is beyond Kutch(above Mumbai). Thus it takes only 10-15 days to cover the Indian peninsula from 8^o *north to the Tropic of Cancer.*

The monsoon begins to retreat by the end of September in north India and reaches the south tip of India only in early December. Thus the withdrawal is spread over a period of nearly two and a half months. The advance and specially the gradual withdrawal of the monsoon leads to a reduction in the rainy period from south to north and consequently a concomitant lengthening of dry season."

2.2.2. The effects of the monsoon during the mine activities

The extraction and transportation of ore becomes difficult during rains due to logistic reasons.

It is important to note that when the rains seasons begin, the large companies are still operating. But, normally the mining activity is limited during the monsoon season and business normally fully resumes by the end of September or the beginning of October.

Some mines in the mining belt of Goa are currently deserted, with machinery covered and barges that normally ferry Goa's workers or transport iron ore tied up at the jetty because of the mining ban.

3. Geology

3.1. Geological history

The Natural Resources of Goa book (2009), written by O.A. Fernandes , has been the main source to describe the geological history of Goa.

The age of the Earth (4.5 billion years) and most of the geological events are several orders of magnitude older than historical or archaeological dates.

The oldest rock in India has been dated at 3.4 billion (or 3,400 million) years. The rock is a trondhjemite gneiss intrusive igneous rocksand which has been also found in Canacona.

These rocks were formed before Goa, India, or even before the Arabian Sea. The trondhjemite gneisses were formed through metamorphism and partial melting of crust, which are denser and richer with ferromagnesian minerals. The earth's crust was made up of much smaller continents and ocean basins that were repeatedly fusing and splitting apart.

The Western Ghats are not true mountains but a faulted edge of an upraised plateau. In fact, the Western Ghats are a result of uplift so the underlying rocks are really ancient (around 2000 million year old). The exposed face of the eastern unsubmerged plate was lifted up to form the scarp of the Western Ghats. That happened during the Eocene (between 45 and 65 m.y.a.), even before India became part of the Asian mainland. Thus, the Western Ghats represent a tectonically active region with high rates of uplift, high summit altitudes, steep slopes, deep gorges and a large erosion tax (with its correspondent high sedimentation yields).

Over 2500 million years ago, new rocks were formed, on top and adjacent to the trondhjemite gneisses. Today, we call the remnants of these younger rocks 'The Dharwar Schists' and they largely consist in folded and metamorphosed volcanic and sedimentary rocks.

Hence, trondhjemite gneisses, Dharwar schists and many igneous intrusives rocks in Goa, conformed the 'Indian shield' which had undergone multiple folding, faulting and melting phase, meanwhile they finally had fused to become a stable mass so they had been remaining for hundreds of millions of years. Those old ‘shield’ rocks of Goa are hidden below a thick laterite cover. In Goa, these underlying rocks include every metamorphic and igneous rock older than 2500 million years.

In Goa, only the laterite and the younger deposits of sand, soil and alluvium are of an age that overlaps some extent with the advent of human beings (approximately 2,000 or 3,000 years ago). The laterite, sand and soil seen today were formed in the last few million years. In addition, there is another stable, “shield” called the Deccan Plateau that occupies the triangular peninsula area of India.

About 237 million years ago a mega continent Pangea (one single gigantic continental mass, meaning “all lands") had formed by accretion of older smaller continents. Thereafter, it was split into a northern continent called Laurasia (North America, Europe and much of Asia) and Gondwana land (Antarctica, South America, Africa, India and Australia) in the south.

The current Arabian Sea and the West Indian coast were born about 150 million years ago when India was slowly drawn away from Africa and Madagascar.

About 65 million years ago, the Indian plate moved into the earth's mantle. As a consequence, there was a lot of volcanic activity on the Indian plate.
Since long time ago, a small part of North Eastern Goa is covered with lava flows (volcanic rocks). Subsequently, there were a series of volcanic eruptions giving rise to the extensive Deccan Traps.

The name of volcanic activity period is the Deccan Volcanic Episode. It occurred in the late Cretaceous to the early Tertiary. Most of the basaltic magma erupted between 60-65 m.y.a. during 2 million of years.

3.2. General geology

TABLE 1.3: STRATIGRAPHIC SUCCESSION OR SEQUENCE OF ROCKS FORMATION IN GOA STATE

<table>
<tr><td colspan="3">LATE CENOZOIC TO RECENT</td><td>Sand, alluvium, lateritic soil and laterite</td></tr>
<tr><td colspan="3">TERTIARY
(Miocene to Pliocene)
(23.8 to 2.60 mya)</td><td>Pink-blue clay with or without basement gravel with sporadic patches of carbonized plant remains/peat</td></tr>
<tr><td colspan="3">UPPER CRETACEOUS TO LOWER EOCENE (65 to 33.7 mya)</td><td>Deccan Trap volcanics and dolerite dykes</td></tr>
<tr><td colspan="3">PROTEROZOIC
(2500 TO 543 mya)</td><td>Basic and acidic intrusives including dolerite dykes, gabbros and ultramafics</td></tr>
<tr><td rowspan="4">ARCHAEAN TO PROTEROZOIC (3000 to 2500 mya)</td><td rowspan="4">DHARWAR SUPER GROUP</td><td rowspan="4">Goa Group</td><td>Vageri Formation: Detrital metasediments (quartzite, metagraywacke and argillite)with some metavolcanics</td></tr>
<tr><td>Bicholim Formation: Banded ferruginous quartzite, Manganiferous chert breccia with pink ferruginous phyllite, Limestone, Pink ferruginous phyllite and Quartz chlorite amphibole schist</td></tr>
<tr><td>Sanvordem Formation: Detrital metasediments including meta-conglomerats, quartzites, metagraywackes and argillites</td></tr>
<tr><td>Barcem Formation: Mainly metavolcanics and metabasites with few metasediments</td></tr>
<tr><td colspan="3">>3000 mya</td><td>Basement trondhjemite gneiss</td></tr>
</table>

Source: Geological Survey of India and own elaboration (2009)

The entire State of Goa is part of the Indian Precambrian shield. In this region, there are green schist supracrustal rocks which overlie a basement consisting of trondhjemitic (Peninsular) gneiss and are intruded by mafics, ultra-mafics and granites. (Fernandes, 2009)

As it is shown on the Table 1.3, Goa is covered by rocks of Dharwar Super Group of the Archaean Proterozoic age except for a narrow strip in the north-eastern corner covered by Deccan trap of the Upper Cretaceous- Lower Eocene age. The Dharwar rocks which extend in a general NW-SE trend are represented by metamorphosed basic and acid volcanic rocks and sediments on the base. (Fernandes, 2009)

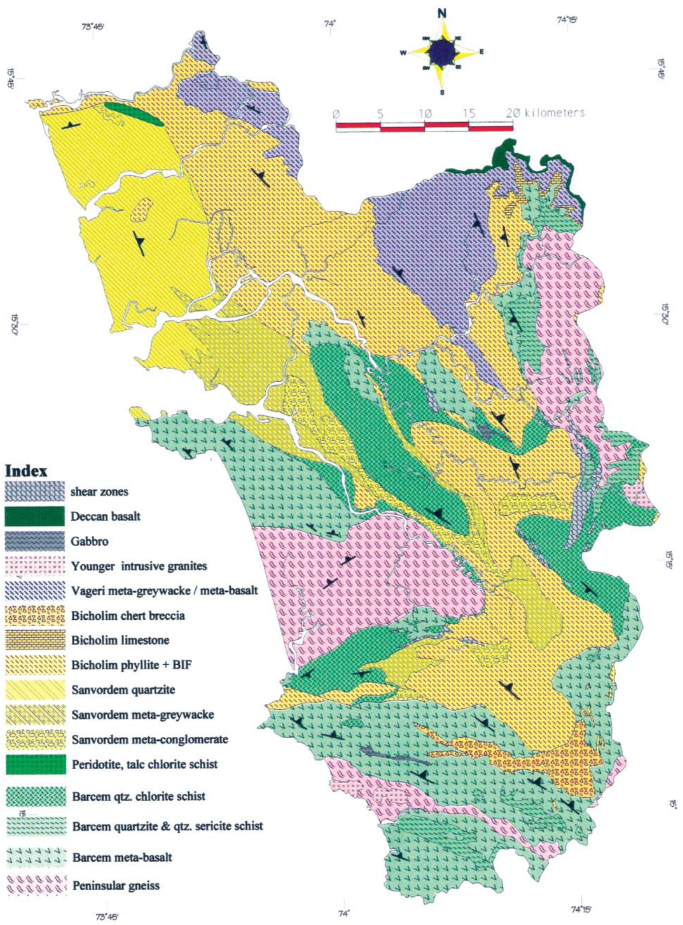
The Dharwarian rocks, including the Goa group, were metamorphosed, folded and faulted in several episodes and were also intruded many times by igneous melts of varying compositions (felsic to mafic to ultramafic) and varying volumes (major and minor intrusive). Also, the pink phyllite horizon with banded ferruginous and manganiferous quartzite constitute the manganese and iron ore bearing horizon and extends over the entire length of Goa from north to south. Thereafter, because of its iron richness, the Bicholim-Rivona formation is described in detail. (GSI, 2006)

The **Bicholim-Rivona** formation includes quartz-chlorite-biotite/amphibole schist with thin lenses of banded iron formation (BIF), ferruginous pink phyllite, magnesian limestone. The formation is extended in NW-SE direction and occupies a large part of Goa. The name of Bicholim formation is formally proposed to these rocks in view of the fact that the biggest iron ore deposits occur at Bicholim taluka. (Fernandes, 2009)

Indeed, BIF with associated iron ore deposits occur in a belt 95 km long and 1 to 14 km wide. The most common names used in India to designate BIF are Banded Haematite Quartzite (BHQ) and Banded Magnetite Quartzite (BMQ). It occurs in a massive, laminated, friable and powdery form. An extensive supergene enrichment yielding iron ore deposits is in BIF. More than 90% of the iron ore supplied to the industry comes from the BIF. (GSI, 2006)

During the Late Cenozoic, the rocks have been subjected to lateritisation as a result of a cover of laterite of varying thicknesses. (Fernandes, 2009)

MAP 1.5: GEOLOGY OF GOA

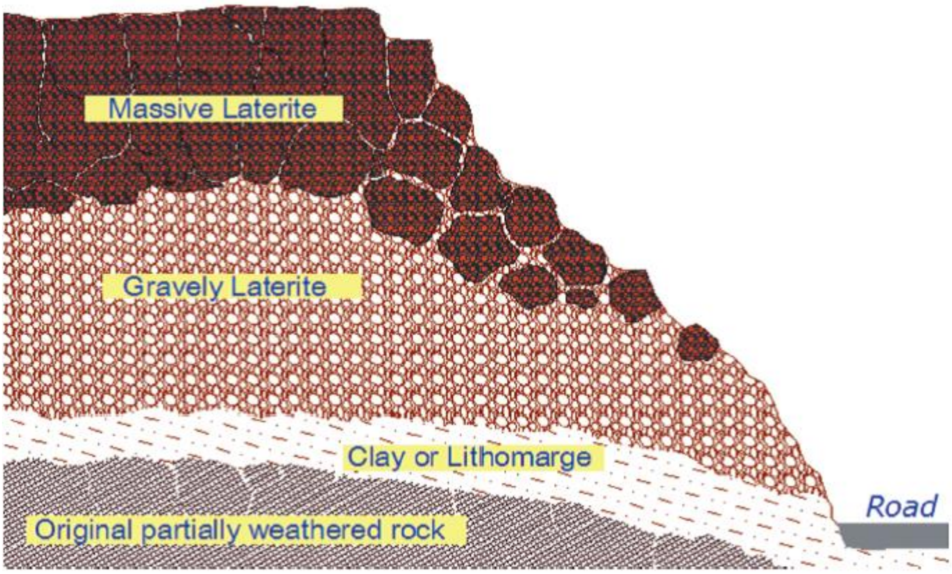


Source: O. A.Fernandes (2009)

3.3. Laterites

The Natural Resources of Goa book, conducted by O.A Fernandes in 2009, explains the following features of laterites.

FIGURE 1.1: A SCHEMATIC SECTION OF A TYPICAL LATERITE PROFILE



Source: O.A. Fernandes (2009)

Laterite is a residual rock layer, hard on top and soft below. They are directly formed by in-situ rock breakdown. A typical laterite profile consists of 8 to 12 meters of massive (hard) laterite exposed on the top of hills that are often plateaus. Those layers are formed due to the high concentration of oxides and hydroxides of iron and aluminium, when other elements are leached away during decomposition of silicate minerals. The original igneous and metamorphic rocks are covered by lithomarge, a layer of clay which lies below the gravely laterite. This lithomarge or clayey laterite is often the cause of landslides along steep slopes mostly during the monsoons.

Most of the edaphic cover in Goa (70% of the area) is made up of laterites. The talukas of Pernem, Bardez, Tiswadi, Ponda, Marmagao, Quepem and Canacona are the places where there are found these laterites layers.

In fact, thanks to the inherent porosity of laterites, they have a good capacity to hold and transmit water. Thus, these are the most important water bearing formations in Goa. Moreover, the topographic setting of laterites controls its groundwater potential.

Laterite profiles consist in an unaltered protolith at the base, an increasingly altered parent rock (or saprolite), iron enriched zones (mottled zone) and, at the top, an iron-rich laterite duricrust or surface layer.

Long-term climatic and tectonic stability, besides a slow geomorphological evolution over periods of 104 - 106 years, are significant to the development and destruction of laterite profiles. This is because laterites are formed and preserved at the Earth's surface, and thus remains exposed to environmental change. Therefore, it is the main reason why there is an extensive lateritization aggravated by the Goan tropical moist climate.

This lateritization process occurs because the parent rock exposed at the surface is subject to low-temperature alteration (i.e. weathering) and associated mineralogical breakdown resulting in the release of mobile elements into groundwater and fluvial systems.

3.4. Origin iron ore

Iron ore deposits are disposed in blankets and near the surface above ground water level in the pink phyllite horizon due to residual concentration in the banded haematite-magnetite-quartzite (Precambrian age) and partly due to replacement of the phyllite by iron oxide. (GSI, 2006)

The iron was deposited in shallow inland lakes. Fresh water has been considered the most likely vehicle for transportation of silica and iron from a lateritic crust. Period of intense deposition was preceeded by a long period of accumulation of dissolved iron and silica in sedimentary basin. (GSI, 2006)
It needs to be remembered that the atmosphere at that time (late Archean- early Proterozoic) is believed to have been rich in carbon dioxide, nitrogen and deficient in oxygen. Thus, large quantities of iron were stored in oceans and lakes. Later on, the photosynthesis provided the air with new oxygen, which was combined with dissolved iron and precipitated, increasing the iron bands. (GSI, 2006)
As it has been said before, the deposits were formed during a residual concentration and enrichment process called lateritisation of the banded ferruginous quartzite and phyllites of the Goa group. Furthermore, Goa has fulfilled some of the main conditions of the developing of that process:
-A favourable geomorphological environment, characterised by limited runoff and lack of aggressive erosion.
-Favourable climatic conditions with a high annual rainfall (Monsoon season). In particular, high humidity and high mean annual temperatures promote chemical weathering and mineral alteration.
-Regions of relative tectonic stability. (Widdowson, 2009)

3.5. Distribution and classification of iron ore deposits

The ore zones follow the regional trend**.** Based on the concentration, iron ore deposits can be broadly divided into 3 parts: the Northern Zone (north of river Madei), Central Zone (between the river Madei and Sanvordem railway station in the south) and the Southern Zone (south of Sanvordem railway station). (GSI, 2006)

In Goa the northern (more haematitic in nature) and central parts contain richer deposits of iron ore but small deposits of low grade manganese ore. In central Goa iron ore deposits are medium size, moderate grade and regular, associated with small pockets and lenses of manganese ore. Moreover, the south is enriched with high grade of manganese ore deposits and only superficial deposits of iron ore.
This pattern of distribution of the iron and manganese ore deposits is essentially due to facies change in the original sedimentation. The depth of ore concentration varies from place to place depending on the

disposition of the parent rock to the slope of the ground in addition to the richness in iron content. In North Goa, iron ore formations are concentrated on high ridges whereas in South Goa, iron ore deposits are concentrated in synclinal basins. (GSI, 2006)
The following list of iron ore deposits in Goa has the important deposits projected in bold letters (GSI, 2006):

North Goa
Advalpale, **Sanquelim, Bicholim-Sirigao** , Nanora, Bordem-Sarvona , , Aravalem , Cudnem-Dignem-Surla Velguem Pale , Pissurlem-Sonshi , Sonal-Davem , Govanem-Malpona ,Balcornem .

Central Goa
Usgaon, Khasti-Codli-Dabhal, Dudal, Suctoli-Tatodi , Kale , Sakvorde , Paikul-Suidem , Kankere, Bolkhane-Gavane-Patwal , Sanvarde (Minor) , Sinnavar (Minor) , Santona-Quirlapale , Sacorda Calay , Tolem - Motto , Barazan - Viliena , Conquirem Bimbol-Sigao , Malinguem , Costi.

South Goa
Nuvem-Kanagini, Sirigao-Undorna , Rivona-Columba , Convorem , Neturlim , Camona-Conda
Betul-Nuem , Sulkorna-Vichundrem .

3.6. Types of ore

The ores near to the surface are hard and compact, meanwhile at depth it tends to be friable and powdery. Sometimes powdery ore is either earthy or even it can be absent. Depending on their physical properties ores are classified as the Table 1.4 shows.

TABLE 1.4: PHYSICAL PROPERTIES OF TYPES OF ORE

Type of ore	Depth	Fe content	Sp.gravity	Other remarks	Colour
Massive	At the surface	63%	4.2	Hard compact and massive	Cherry red to steel-grey
Bedded	At and near the surface	59-62%	3-3.4	Hard and compact	Cherry red to bluish-black and steel-grey
Platey	At and near the surface	58-62%	3-3.2	Thin plates of iron ores; thickness 2-3 cm cemented by Ferruginous or clay material	

Brecciated	At and near the surface to 3-8 m	56-62%	2.8-3.2	Small angular pieces of haematite cemented in lateritic/ferruginous matrix	
Mixed	At surface	45-59%	2.5-3	Patches, lenses and bands of haematite mixed with laterite	
Earthy ore	Below laterite /Mixed ore zone	55-58%	3.0		Bluish green to yellowish green
Laminated/Biscuity ore	Between Surfacial lumpy and deep blue dust	59-65%	2.9-3.1	Ribbed appearance, friable crumble into powder	
Concretionary ore	Present in laterite in 20 -30%	57-62%	3.1-3.4	Partly haematite	
Blue dust /powdery	Below hard compact ore and laminated ore	63-68%	2.8-3.0	Consist of fine haematite and magnetite grains loosely packed with lot of voids with lot of voids and pore spaces	Blue to blackish

Source: Geological Survey of India (2006)

However, only three are really remarkable: the massive ores, the laminated ores and the powdery because they have the highest iron contain rates in comparison with the rest.

3.7. Size and Quality of ore

On one hand, the iron ore is classified into the following four categories on the basis of size (Gokul, 2012):

- **Lumpy** → + 12cm
- **Smalls** → 2 – 12 cm
- **Fines** → 6 mm – 2 cm
- **Powdery (Blue dust)** → - 6 mm

On the other hand, the iron ore is classified into the following four categories on the basis of grade (IBM, 2011):

- **High grade**: 65 % and above Fe
- **Medium grade**: 62 - 65% Fe
- **Low grade:** 60 - 62% Fe
- **Unclassified:** The range of minimum and maximum value of chemical constituents is too wide to be fitted in to any of the above grade.

The average chemical analysis of Goan samples is given in the Table 1.5:

TABLE 1.5: AVERAGE CHEMICAL ANALYSIS OF TYPES OF ORE

Types of ore	Fe %	SiO_2 %	Al_2O_3	Mn%	TiO_2%	S%	P%	Combined H_2O %
Lumpy	56-64	1-5	2.8-8.4	0.06-0.76	0.20-0.23	0.020-0.028	0.048-0.057	2.16-7.92
Powdery	60-67	1-4.8	1.06-4.82	0.03-1.46	0.22-0.26	0.021-0.023	0.042-0.047	1.57-6.5

Source: Geological Survey of India (2006)

Thereby, the previous table shows the mainly iron ore size: lumpy ore, essentially made up of haematite and powdery ore, conformed by magnetite.

The Iron ore deposits in Goa are fines oriented (around 80% of the deposits). Another peculiarity of Goan iron ore deposits is that the lumpy ore has lower grade than the powdery ore.
The lumpy ores are comparatively soft, porous in nature owing to the varying proportions of laterite and shaly mixture in them. The powdery ore or blue dust ore is extremely fine grained, friable and includes considerable amount of pores and voids. (IBM, 2011)

3.8. Principal iron ores

The iron ore deposits consist essentially of haematite and partially of magnetite, limonite and goethite.

The iron is composed by some chemical compounds with other elements which exist in some minerals. Oxides (haematite and magnetite) are the most prominent of the iron ores found. Other forms are carbonates, hydroxides, sulphides and silicates (IBM, 2011). The table 1.6 shows a list of common iron minerals and its properties:

TABLE 1.6: COMMON AND PROPERTIES OF IRON MINERALS

Mineral	Composition	Iron Content (%Fe)	Specific Gravity	Hardness (Moh's Scale)	Colour
OXIDES					
Hematite (Alpha) and Martite	Alpha-Fe_2O_3 (Hematite pseudomorphous after magnetite)	70	4.9-5.3	5.5-6.5	Steel grey to red
Turgite	2 $Fe_2O_3.H_2O$	66.1	4.2-4.6	6.5	Brown to red
Goethite	$Fe_2O_3.H_2O$	62.9	3.4-4.2	5-5.5	Brown to red Brown to yellow
Limonite	2 $Fe_2O_3.H_2O$	60	3.4-4.2	5-5.5	
Lepidocrosite	$Fe_2O_3.H_2O$	62	4.09	5	Brown to reddish brown
Ilmenite	$FeTiO_2$	36.8	4.5	5-6	Black to brownish black
Maghemite	Gamma-Fe_2O_3	69.9	4.88	5	Brown
Magnetite	Fe_3O_4	72.4	5.17	5.5-6.5	Black, blue or brown black
CARBONATES					
Siderite	$FeCO_3$	48.2	3.7-3.9	3.5-4.5	Ash grey to brown
SULPHIDES					
Pyrite	FeS_2	46.6	4.8-5.1	6-6.5	Brass yellow
Marcasite	FeS_2	46.6	4.9	6-6.5	Light brass yellow
Pyrrhotite	FeS_2	61.6	4.4-4.65	3.5-4.5	Bronze yellow
SILICATES					
Chamosite	$(Mg.Fe.Al)_6(Si.Al)_4O1_4(OH)_8$	33.42	3-3.5	3	Green to light yellow

Source: Indian Bureau of Mines (2011)

❖ The nonsilicate minerals: Oxide Minerals

The most widespread group of minerals, after the silicates, are the oxides. Among them, the oxides of iron and of titanium are the most common and important. Although, there are other minerals which contain iron compounds: Limonite, Goethite, Pyrite and Siderites. (IBM, 2011)

➢ Haematite

Is the most abundant iron ore mineral and is the main constituent of the iron ore industry because of its high grade quality and lumpy nature.

It occurs in three different forms:

The specular hematite, it forms masses (blocky) or platy crystals. Its colour is black to steel grey with bright metallic and it is opaque. The micaceous hematite is a common accessory compound of feldspathic igneous rocks, like granite, which gives a deep red colour and a metallic luster. The common red hematite is founded in rocks and soils. It occurs in sedimentary and metamorphic rocks of great size. In appearance, it is massive and compact, columnar, granular, stalactitic, may be form dense hard lumps or earthy. Has a deep dark red pigment in the form of powder and it is opaque. (IBM, 2011)

- **Magnetite**

It is the second most economic important iron bearing mineral of economic importance. It may occur as distinct crystals in rocks but is generally present in small grains. It also occurs in considerable or irregular masses, some large enough to be rich ore bodies. Magnetite is resistant to weathering. It may alter to limonite or martite (ferric oxide). (IBM, 2011)

3.9. Uses of iron

Pure iron has relatively few and quite uses. Its good ductility makes it suitable for the manufacture of appliance parts, relatively low electrical resistance and high magnetic permeability lead to its use in many types of electrical equipment, generator fields, etc. Commercially, iron is a very important metal. (GSI, 2006)

Iron ore is the basic raw material used, for example, in cement, coal washeries, ferro-alloys, foundry, vanaspati (hydrogenated vegetable oil) and glass industries (vitreous enameling).However, the main uses of this ore are making pig iron, sponge iron and finished steel (alloy of iron with carbons and other elements depending on end use). (GSI, 2006)

The **pelletisation** is a method in which finely divided material is rolled in a drum or on an inclined disk, so that the particles cling together and roll up into small, spherical pellets. (GSI, 2006)

The **pig iron** is one of the basic raw materials required by foundry and casting industry for manufacturing various types of castings for the engineering section. (GSI, 2006)

Sponge iron (known as DRI) is produced by direct reduction of high-grade iron ore or pellets to metallic iron ore in solid state by using coal or natural gas as reductant. Sponge iron is a good substitute alternative for scrap. The availability of indigenous metal scrap is scarce, and therefore, to meet the domestic demand scrap is usually imported. (GSI, 2006)
Iron is an important constituent of some **ferro-alloys** which are used in steel industries to impart some special qualities or are exported. (GSI, 2006)

Iron ore lumps and powder containing +58% Fe are normally used in the **cement** industry as they improve burning properties, provide colour and balance the composition of the mix. (GSI, 2006)

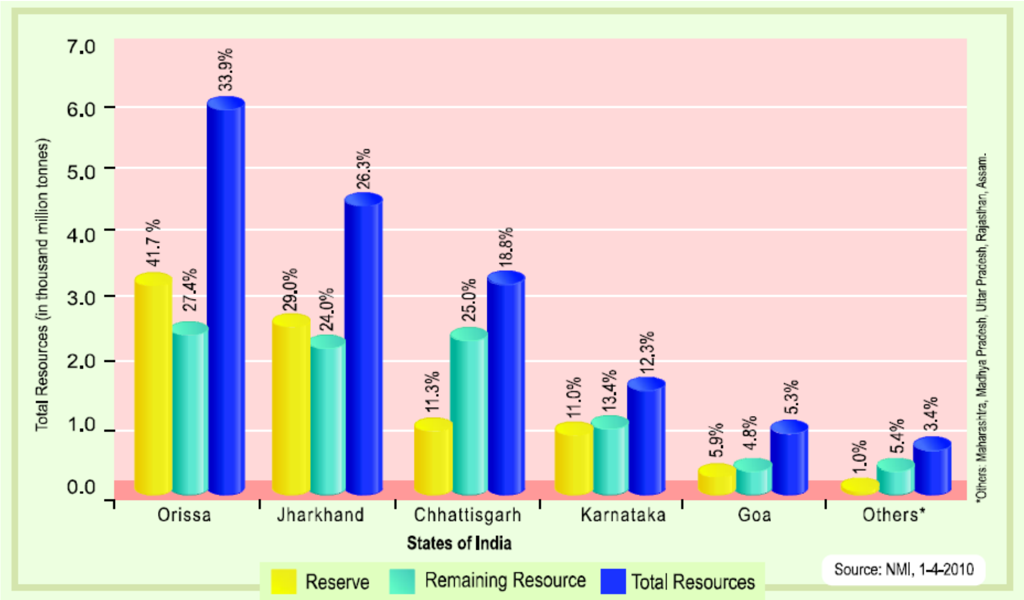
3.10. Reserves/deposits of iron ore

In the initial years little efforts were made to carry out systematic exploration of the deposits for assessing their gradewise reserves. In the 50’s, the absence of scientific prospecting, uncertainly about the reserves and quality loomed large. The first attempt to estimate the reserves of iron were made by Gokul (1972) based on the exploration data available until 1969.

First of all, we must talk about three keywords to understand the concepts:

- Iron **resource** : Iron amount is actually in the ground.
- Iron **reserves** are defined as the amount of measured resource iron that could be expected to be economically mineable under the current economical and technological conditions. Therefore iron reserves represent a small and changeable percentage of iron resources, changing based on the price of iron , the technology used to extract it, and other factors.
- **Remaining resource** is the amount of total resource present after the finished mining activity.

FIGURE 1.2: RESERVES AND TOTAL REMAINING RESOURCES OF HEMATITE IRON ORE



Source: Indian Bureau of Mines (2011)

Total resources of iron ore in the country is around 28.52 billion tonnes(National Mineral Inventory) as on 2010. As it is shown on the Figure 1.2, around 96% of hematite resources are confined in the States of : Orissa(33.9%), Jharkhand(26.3%), Chhattisgarh(18.8%), Karnataka(12.3%), Goa(5.3%) and others: Maharashtra, Uttar Pradesh, Rajasthan, Assam, etc.(3.4%). (IBM, 2011)

Of the estimated 17.88 billion tonnes of hematite available, 8.09 billion tonnes(28%) are under 'reserve' category and 9.79 billion tonnes (in Goa only 713 Mt (5%)) under 'remaining resource' category. In India, around 70% of the hematite reserves, are located in the States of Orissa and Jharkhand only while, Chhattisgarh and Karnataka account for around 11% each of the hematite reserves. (IBM, 2011)

Whereas total resources of magnetite are estimated at 10.64 billion tonnes of which reserves are merely 0.02 billion tonnes (207 Mt) located mainly in Karnataka and Goa while 10.62 million tonnes (in Goa , 214 Mt , 2%) are remaining resources. (IBM, 2011)

Concretely, Goa has a small iron reserves amount compared to the rest of India.

Is important to note the divergence of concerning opinion about the amount of reserves: Parrikar(Chief Minister of Goa) told:*"There are 2 billion tones of iron ore reserves in the state, while IBM has estimated the ore to be 1.2 billion tones. So there is something that is not consistent"*. (The Economic Times, 2013)

Also, we need to look carefully at iron ore reserves in Goa quoted by Shah Commission or GSI which gives different figures in different reports. GSI October 2006 report estimate the reserves of 730 Mt. In August

2011, GSI quoted a figure of 927 Mt for both hematite and magnetite type ores in Goa. NCAER report-2002 shows reserves of 2006 Mt comprising all grades. So there is a large discrepancy in official figures and claims made by the miners.

Really, The IBM data are reliable (as reflected in the rejoinder of NCAER's). The total reserves are 920 Mt (713 Mt of haematite and 207 Mt of magnetite).

Many mines would be exhausted much earlier than predicted: *"Around 14 mines would be exhausted within five years and 15 to 25 mines would be exhausted within 10 years",* (M. B. Shah, 2012).

The authors argue that an assumption of a useful life of 25 years would be incorrect as the reserves will last only for 21 years. They suggests that for 713 mega tonnes of ore to be extracted at an annual rate of 33 mega tonnes would take only 21 years for the reserves to end. (Venkatesan, 2012)

For conserving iron ore for 50 years, capping is a must and its extraction should not exceed more than 12.5 Mt per year for quality grades. That type of planning is contemplated under Rule 10 of Mineral Conservation and Development Rules, 1988 for conservation of mineral, scientific mining and healthy environment.

3.11. Future Outlook

On one hand, the only source of primary iron is iron ore, used directly as lump ore or converted for example to briquettes, concentrates, pellets, or sinter.

Hence there is need for identifying new sources of iron. The only material which can meet this demand is the banded ferruginous quartzite, extensively present in the Barazan- Viliena, Tolem- Motto, Bimbol, Sonol-Davem areas. These ores with 30-40 % Fe (partly magnetite and partly haematite) will account for very large reserves, say a few thousand million tonnes. The ore will however require application of appropriate technology for beneficiation and ore concentration. (Gokul, 2012)

The reserves of high grade iron ore are limited. Instead, India's low grade ores are relatively abundant. Therefore, it would be necessary a blend with low grade ores in order to ensure the conservation.

4. Hydrology

4.1. Backdrop in India

Of the six hundred billion cubic meters of ground water pumped every year throughout the world, India extracts 150 billion cubic metres. This figure represents 32% of the total water pumped distributed as; 9% for drinking, 89% for agriculture and livestock and 2% for industry (Chachadi, 2009)

The total utilisable water resources of India, both surface and groundwater, can broadly be taken as 104 MHM of which surface water contributes 68 MHM and groundwater 36 MHM. The estimated net extraction of groundwater development in the country is about 28%. (Chachadi, 2009)

4.2. Surface wate

4.2.1. Drainage

Great volumes of monsoon water descend within the watershed areas and then are drained through the major rivers into the sea.

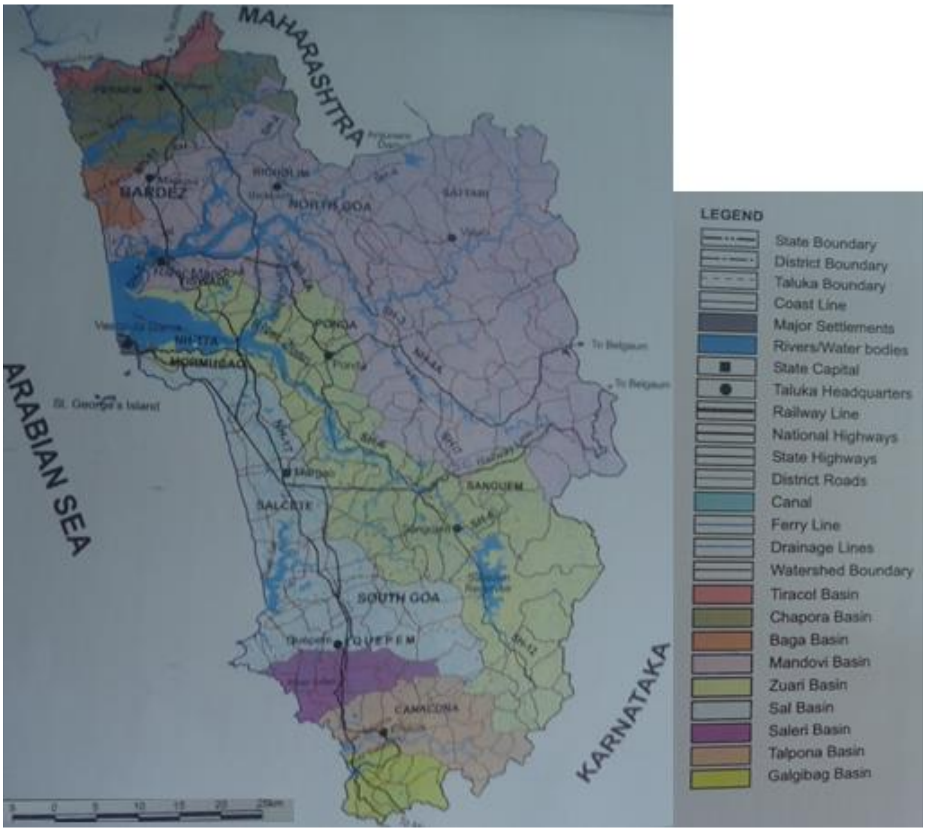
The nine major rivers of Goa are Tiracol, Chapora, Baga, Mandovi, Zuari, Sal, Saleri, Talpona, Galgibag. Those rivers, which are navigable throughout the year, have their origin in the Western Ghats. After that, they cross the State flowing in a westerly direction and finally drain into the Arabian Sea (except Sal River due to the west coast fault). Early soon, the rivers lose their energy as they pass through the midlands and the estuarine plains before meeting the sea. Most of the rivers join the sea through estuaries. The Zuari and Mandovi Rivers have got the key estuaries because with their tributaries drain together 2553 km^2 (70% of the total geographical area of the state). Tiracol and Chapora rivers start in the Maharashtra state and Mandovi originates in Karnataka. Another 6 rivers originate and flow exclusively within the state boundaries. (Goaenvis, 2005)

TABLE 1.7: THE MAIN RIVER BASINS

River Basin	Length within the State/kms	Within the salinity zone /kms	Basin area in Sq. kms
Tiracol	26	26	71
Chapora	32	32	255
Baga	10	10	50
Mandovi	52	36	1580
Zuari	145	42	973
Sal	40	14	301
Sateri	11	5	149
Talpona	32	7	233
Galgibag	14	4	90

Source: Author and Central Pollution Control Board (2007)

Map 1.6 : Drainage



Source: Department of Science, Technology and Environment (Goa), Central Ground Water Board (Bangalore) and Department of Water Resources, Goa (2006)

Each river with their tributaries has its own basin as it is shown in the map 1.6. There are two large river basins (Mandovi and Zuari), 5 medium river basins (Terekhol, Chapora, Sal, Talpona and Galgibag) and two smaller basins (Baga and Saleri).

Although about 8570 MCM are collected in the rivers, nearly 8436 MCM finally goes to the sea. That fact is because of the steep slopes and the short lengths of the rivers that make the water run swiftly to the sea. (Chachadi, 2009)

When the rivers leave the Ghats they rapidly come to the main sea level becoming saline. So it is evident that 50% of the length of the river is saline meanwhile only the 50% of the water in the Ghats is fresh (Sadhale, 2010).The salinity of the water is different between monsoon and non-monsoon periods, so the water of the wells tends to increase its salinity as the summer advance (Goa Foundation, 2010). Dry weather flow is essentially from contribution of ground water in the form of springs and groundwater seepage.

4.2.2. Surface water use

The surface water in Goa is predominantly used for domestic, irrigation and industrial purposes. The irrigation requirement from major, medium and minor (surface water) schemes is about 1146 MCM. Thus the total water requirements would be nearly 1329 MCM, which is just about 15% of the surface water potential (8437 MCM) of Goa state. (Chachadi, 2009)

There are many uses of surface water and most of these inevitably require large amounts of water:

- Industrial use: there are 20 industrial polygons in Goa.
- Pilgrim centres: the temples are built along the riverbanks and use the water for bathing purposes.
- Fishing, Shrimp and Shell farming: Goa has a coastline of 105 km and inland waterways up to 50 km. Hence, the coastal and inshore waters are very rich in fishery resources.
- Salt pans: Goan salt had been considered one of the best in quality. With over 200 salt-pans still existing in 13 villages of 4 talukas: Pernem, Bardez, Tiswadi and Salcete. Goa produces around 35,000 metric tons of salt annually.
- Water Sports: The long coastal area offers a wonderful opportunity to indulge in all sorts of water sport activities. Although most of the water activities are along the beaches, there is a considerable amount of it practiced at the rivers as well.
- Propagation of wild life: The areas in and around the various wild life and bird sanctuaries have a high usage of water. (CGWB, 2010)

The drinking water supplied to the urban is mostly surface water schemes but there are many people depending on groundwater. The major water zone supplies schemes are tapped from surface base flow and cover urban as well as rural population in the respective zones:

TABLE 1.8: WATER SUPPLY SCHEME

Water Supply Scheme	Area
Opa	Urban areas of Ponda, Margao, Mormugao and Panaji and rural population of 53 villages
Assonora	Urban areas of Mapusa and Calangute and rural population of 22 villages
Sanquelim	Sanquelim, Bicholim towns and the near by villages located in the mining areas
Canacona	Canacona town
Salaulim	South Goa: 71 villages and the major towns of Mormugoa, Vasco, Margao and Fatorda.

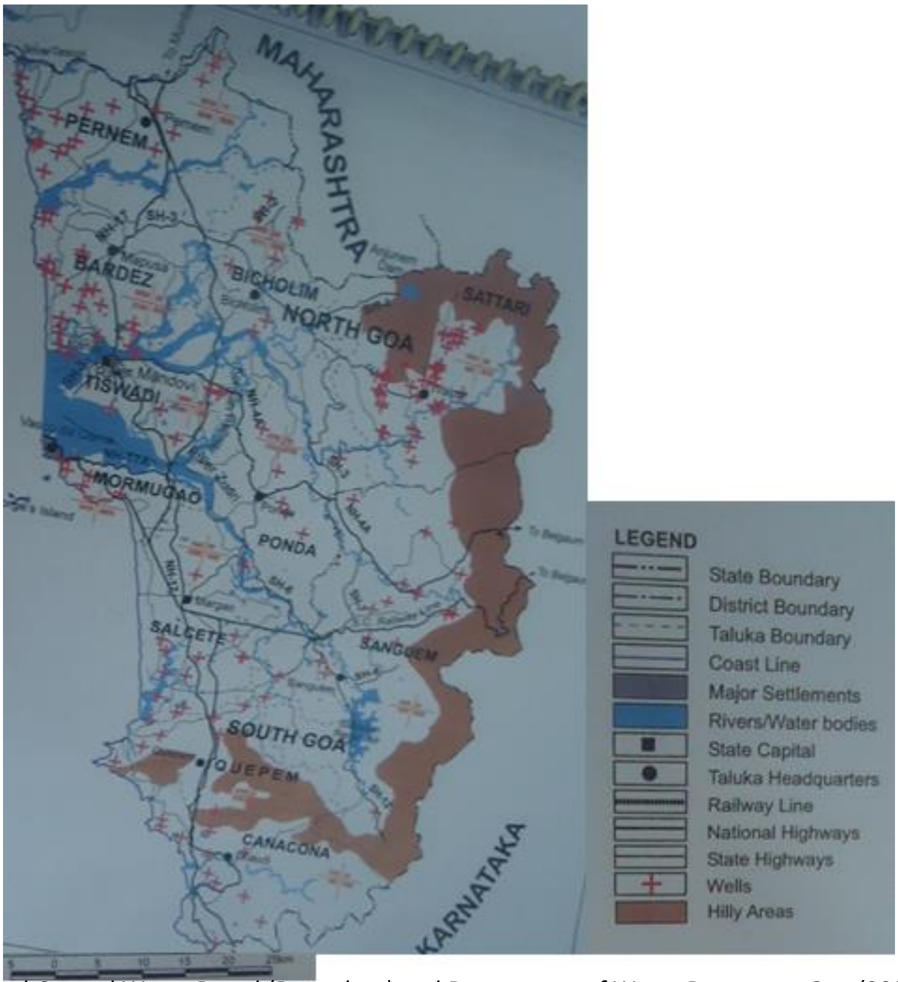
Source: Author and Central Ground Water Board (2007)

4.3. Groundwater

Generally the groundwater is generally good for domestic, irrigation and industrial purposes except in the areas inundated by salt water during high tide and its vicinity. The groundwater in the state is mainly used for drinking and industrial purposes followed by agriculture to some extent. (Chachadi, 2009)

The ground water resources available for future use are estimated to be 425 MLD. Therefore, present total groundwater drafts including domestic, industrial and irrigation works out to be about 400 MLD. (Chachadi, 2009)

MAP 1.7 : GROUND WATER (WELLS)



Source: Central Ground Water Board (Bangalore) and Department of Water Resources, Goa (2006)

Indiscriminate sinking of boreholes in the urban areas and industrial estates has been a matter of great concern. As per MI Census 2000-01, there are 4,620 dug wells, 30 shallow tube wells and 60 deep tube wells in the State for irrigation purposes. Over the years the groundwater table is lowering at an alarming rate indicative of poor recharging capacity. Micro-watershed level studies carried out in the coastal belt and mining areas respectively have indicated moderate to severe water stress conditions in majority of the sub-watersheds. (Chachadi, 2009)

The balance of the water demands is derived mainly from groundwater sources. There is an urgent need for identifying groundwater potential areas and use exhausted mine pits for rainwater harvesting to meet the ever-increasing demands for fresh water.

TABLE 1.9: WATER POTENTIAL IN GOA

Ground Water Prospects	Geomorphic Units
Excellent to Very Good	Valley Fill, Flood Plain, Beach ridge
Very Good to Good	Coastal Plain
Good to Moderate	Intermontane Valley
Moderate to Poor	Pediment, Etched Pediplain, Dissected Laterite Upland, Denudational Slope, Dissected Plateau Top-Low, Medium and High.
Poor	Salt Flat, Mud Flat, Tidal Flat, Beach, Denudational Hill- Low, Medium and High, Denudational Hill-High(Western Ghats), Residual Hill, Mining area, Quarry.

Source: Central Ground Water Board (2007)

The groundwater occurrence and movement, productivity and recharge to the aquifers are dependent on the degree of weathering and fracturing, geomorphological set-up and precipitation. The most important feature is that the quality groundwater depends of geomorphic units.

Assuming 10% rainfall recharge to groundwater and using the annual average rainfall of 3500 mm, the groundwater potential of Goa has been worked out to be of the order of 152 MCM (CGWB ,2009).

4.3.1. Groundwater recharge and discharge

In Goa, the main source of groundwater's recharge comes from southwest monsoon.

The magnitude of recharge the groundwater also varies from place to place depending on the nature of the surface conditions like intensity of rainfall, infiltration capacity of soil, geomorphology of the area and slope of the terrain.

The water levels in the wells generally reach close to the ground surface during the month of July under normal rainy season. However, studies in the coastal alluvial belts indicate that the groundwater recharges at a much faster rate due to high permeability of the surface soils. The groundwater in the coastal plains also drains at a faster rate to the sea.

4.3.3. Hydrogeology: Aquifers

An aquifer is a geological formation or group of formations which can hold and yield water. Basically, the aquifers can be classified in two type of aquifers namely unconfined and confined aquifer. (Nadkarni, 2012)

Phreatic aquifer is a permeable bed only partially filled with water and overlying a relatively impervious layer. Its upper boundary is formed by a free water table or phreatic level under atmospheric pressure. Confined aquifer is the one which is completely saturated with impervious upper and lower layers. (Nadkarni, 2012)

The water of mining belt is stored in two main different types of aquifers:

-On the top, the lateritic layer, which is the most extensive in the area, has been very exploited due to mining and other human activities. There are both kinds of aquifers, confined and unconfined.
-The second is the powdery iron ore formation at depth. The powdery iron is highly porous, permeable and completely saturated with water, whereas the hard rock formations only bear water in their network of clefts and fractures .There is the confined aquifer.
Considering 35% yield, the total quantity of water likely to be confined to this area alone is expected to be about 525 MCM. (CGWB, 2010)

4.3.4. Mining and water

In Goa, mining has affected groundwater, surface flows and drainage patterns. The mining activity causes the total destruction of our water bodies. The causes for depletion of water resources were mainly due to iron ore mining activity and dumping of mine rejects on the hilly terrain.

In Goa alone, the government itself has acknowledged that over half of the 300 odd mining leases are located close to water bodies. Data tabled in the Goa Assembly revealed that several of the 182 mining leases exist within one kilometre of a major irrigation project, the Selaulim dam, which provides drinking water to six lakh people in south Goa. Additionally most of the mines are located in close proximity to either of the two rivers Mandovi and Zuari. Most of the mines are within 15 km of the river loading points. (Guns, 2012)

Goa has an advantage over other exporting regions in the country in view of the rivers which are excellent navigational channels helping the barge-based transport of ore from the mining areas to the port. Marmugao Port, the single port on the western seaboard of the country with a sophisticated high capacity Mechanical Ore Handling Plant for iron ore almost represents the 50 % total iron ore exportations in the country. (Goaenvis, 2005)

II. MINING EFFECTS ON ABIOTIC ENVIRONMENT

During the working life of mine, air, water, noise and land use are likely to be affected due to mining of minerals and associated activities.
Allied operations such as transport of materials, operation of workshop, drilling, blasting... affect the air, water and noise environment.
The magnitude and significance of these impacts on environment due to mining will depend on the size and scale of mining activity in conjunction with the topography and climatic conditions of the area, the nature of mineral deposits, method of mining and capacity of mines, agricultural activities in the region, etc.

1. Air quality

According to Central Pollution Control Board (Goverment of India, 2007), the large-scale mining has the potential to contribute significantly to air pollution, especially in the operation phase. Mining operations mobilize large amounts of material, and waste piles containing small size particles are easily dispersed by the wind.
The impacts of mining and mineral processing operations on the air quality depend on the nature and concentrations of the emissions, meteorological conditions and the nature of the receptors humans, flora, fauna or materials. The major air pollutants from mining include:

TABLE 1.10: THE AIR POLLUTION FROM MINING ACTIVITIES

Air Pollutants	Activities in Mines
SPM	Drilling
SPM , SO_2, NO_X	Blasting
SPM	Loading and Unloading
SPM	Haul Road
SPM, SO_2, NO_X	Transportation
SPM	Crushing of ore
SPM	Waste / Top soil handling

Source: Central Pollution Control Board (2007)

SPM – Suspended Particulate Matter
SO2 – Sulphur Dioxide
NOx – Oxide of Nitrogen

• Particulate matter (Dust) of various sizes and chemical constituents.

Dust is the main and largest air pollutant produced by the iron ore mining.

Dust is being produced from a number of sources and through number of mechanisms such as land clearing, removal of top soil (during opening up of new areas), drilling, blasting, crushing and screening, processing of ore, loading and unloading of material on site and subsequent transport off the site. During excavation, the dust generation is much less because of high in-situ moisture content in the ore itself. (CPCB, 2007)

For most of the mining operations, the major sources of dust are mine haul roads, followed by drilling and then blasting. The major cause of dust generation is overloading and over speeding of trucks.

It should be noted that the fugitive dust emissions (those emissions which could not reasonably pass through a stack, chimney, vent or other functionally-equivalent opening) are produced by the contact of the tires with the unsealed road surface and are affected by the total distance travelled. Each stage of material transfer involves loading, transport and unloading, also generate fugitive dust. (CPCB, 2007)

• Gases, such as, sulfur dioxide and oxides of nitrogen, carbon monoxide from combustion activities(vehicular exhaust).

Diesel power stations, diesel operating drilling machines, blasting and vehicles produce $NO_{x,}$ SO_2 and CO emissions, usually at low levels. Oxides of nitrogen can react in the atmosphere with hydrocarbons to produce photo-chemical smog. In addition to this, the sulphur dioxide and oxides of nitrogen can generate an acid. (CPCB, 2007)

The National Ambient Air Quality Standards notified under the Environment (Protection Rules) are given in the table 1.1:

TABLE 1.11: AIR QUALITY STANDARDS

Pollutant (µg / m^3)	Time Weighted Average	Industrial Areas
Sulphur Dioxide SO_2	Annual Average * 24 Hours **	80 120
Oxides of Nitrogen As NO_2	Annual Average * 24 Hours **	80 120
Suspended Particulate Matter SPM	Annual Average * 24 Hours **	360 500

*Annual Arithmetic mean of minimum 104 measurements in a year taken twice in a week 24 hourly at uniform interval
** 24 hourly / 8 hourly values should meet 98% of time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

Source: Central Pollution Control Board and own elaboration (2007)

TABLE 1.12: AVERAGE ANNUAL VALUES AND POST-MONSOON (2007)

	Outside Mine		Inside Mine	
Pollutant	**Annual Average µg / m3**	**Post-monsoon µg / m3**	**Annual Average µg / m3**	**Post-monsoon µg / m3**
SO_2	14.03	10.3	22.28	14.5
NO_2	9.32	6.53	12.41	10.3
SPM	328	240	508	372

Source: Central Pollution Control Board and own elaboration (2007)

First of all, in the mining area, the concentration values inside the mines are higher than the outside area due to the different sources of air pollution by mining activities, as it has been said before.
The Table 1.12 shows that during the Monsoon the huge rainfall cleans the polluted air so the concentration of those substances.

The concentration of sulphur dioxide and oxides of nitrogen were almost remarkable because the annual average value is not so high and the emissions represent a small percentage of the total air impacts due to mining. However, the SPM are really important. The large amount of those concentrations is caused by the innumerable processes from mining which origins major sources of air pollution, as it has been said on the previous paragraphs.

2. Noise and ground vibration generation

The Comprehensive industry document on iron ore mining (2007), written by the Central Pollution Control Board (Government of India), has been the main source to describe the noise and ground vibration impacts.

Mining operations usually generate noise and ground vibration (higher frequency range) during different stages of mining and handling of ores.

In case of ore extraction, noise is due to drilling, blasting, excavation, sizing and transportation of ores.

In case of ore processing, noise is due to operations like crushing, screening, washing, storage and dispatch of ores. These noise generating sources can be grouped into two categories:

- Fixed plant machineries such as crushers, grinders, screens, conveyers, generate noise and vibration.
- The mobile plant used on-site associated with drilling, blasting, loading, haulage or service operations cause noise.

Vibration is the term used to describe the reciprocating motion in a mechanical system and can be defined by the frequency and amplitude of the oscillations.

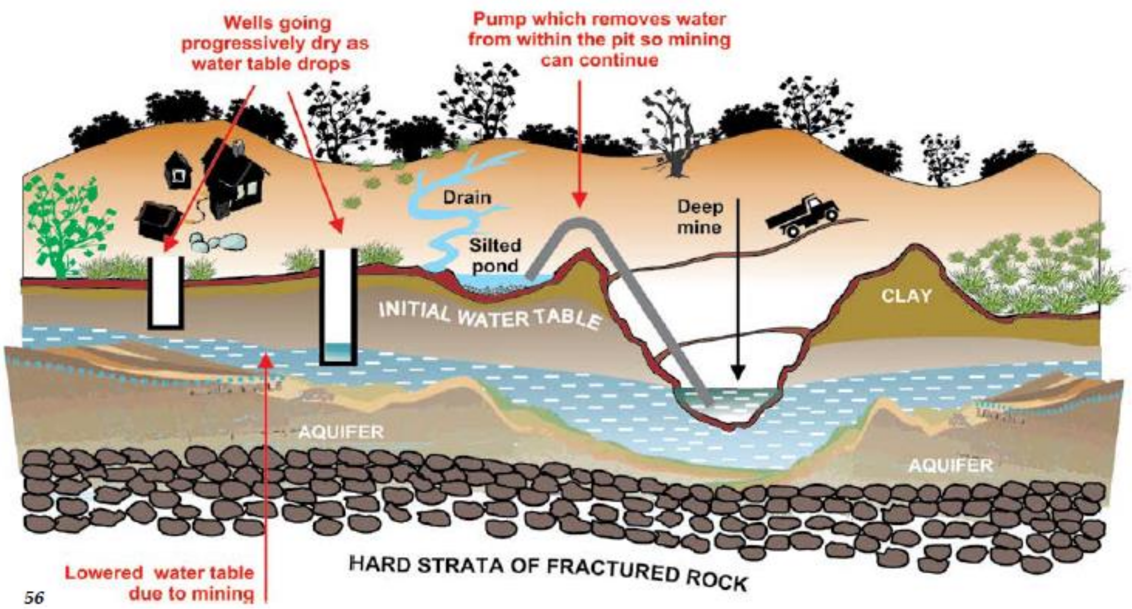
The vibration and air blast from blasting can lead to a structural damage. When an explosive charge is detonated in a confined drill hole, intense strain waves are transmitted to the surrounding rock and large amount of pressure and temperature develops with in a very short time interval. The use of explosives creates airborne pressure fluctuations. The process melts, flows, crushes and fractures surrounding rocks. The excess explosive energy propagates the disturbance (seismic wave or ground vibration) away from the explosion site.

3. Impacts on water regime

Mining and its associated activities use huge quantity of water for various purposes and also affect the hydrological regime of the area. Extraction of different minerals also leads to water pollution due to heavy metals, acidic water, increased suspended solid etc. The most significant impacts due to mining are the effects on water quality and availability of water resources.

Figure 1.3 is a scheme that shows main impacts of mining over hydrology.

FIGURE 1.3: THE MOST IMPORTANT WATER IMPACTS DUE TO MINING



Source: Central Pollution Control Board (2007)

The Dr. A.G. Chachadi, doctorate in geology, explain that when mining started in Goa in the 1950s, they were superficial manual operations, not envisaged to go deep below ground. Also explain that today, however, all mines having mechanized, they go well below the water table, ruining it completely. When mining activities go below the ground water table, water from adjacent areas migrates into the mining pit, leading to its flooding, preventing operations. Huge pumps simply pump out the ground water, in order to allow mining to proceed. Eventually, the entire ground water table is either emptied or lowered, rendering village wells dry.

The damage done to the hydrogeological regime cannot be reversed in several decades. Though pits accumulate water, the impounded water is sterile, biologically dead and hardly of use to village communities because of its sediment load.

Mining and associated activities have quantitative and qualitative impacts on the water regime in and around the mines.

The main water pollution sources are: effluent generated from the Ore Processing Plant, pit water discharge from mines, waste dump areas, ore handling and stockpile areas and mine proper and haul roads.

Thereafter, on the next paragraph there are shown four principal impacts belonging to mining activity which directly affect the Goan hydrology. This information is provided by the Guidebook for Evaluating Mining Project EIAs published by Environmental Law Alliance Worldwide in 2010.

3.1. Acid mine drainage and contaminant leaching

Acid mine drainage is the outflow of acidic mine waters from active and inactive metal mines as well as from the surface mining waste dumps, beneficiation and large constructions activities. Acid drainage and contaminant leaching is the most important source of water quality impacts related to metallic ore mining.

When mined materials (such as the walls of open pits and underground mines, tailings, waste rock, and heap and dump leach materials) are excavated and exposed to oxygen and water, acid can form if iron sulfide minerals (especially pyrite) are abundant. The pyrite oxidizes to form ferric hydroxide, sulphate and hydrogen ions. The liberation of hydrogen ions lowers the PH and causes increased acidity in water passing.

The acid will leach or dissolve metals and other contaminants from mined materials and form a solution that is acidic, high in sulfate, and metal-rich.
Leaching of toxic constituents, such as arsenic, selenium, and metals, can occur even if acidic conditions are not present. Elevated levels of cyanide and nitrogen compounds (ammonia, nitrate and nitrite) can also be found in waters at mine sites, from heap leaching and blasting.

The metals are particularly problematic because they do not break down in the environment.
Acid mine drainage dissolves toxic metals and many streams impacted by acid mine drainage have a pH value of 4 or lower. Moreover, the iron may cover the stream bottom with an orange-red coloured slime called yellowboy. Carried in water, the metals can travel far, contaminating streams and groundwater for large distances.

The iron deposits to the bottom and persist in the stream for long periods of time. This is an important problem by acid mine, because the drainage can continue indefinitely causing damage long after mining has ended. Even with existing technology, acid mine drainage is virtually impossible to stop once the reactions begin.

3.2. Erosion of soils and mine wastes into surface waters

The soil and sediment are eroded and degraded so the water's quality decreased.

Sediment-laden surface runoff typically originates as sheet flow and collects in rills, natural channels or gullies, or artificial conveyances. The ultimate deposition of the sediment may occur in surface waters or it may be deposited within the floodplains of a stream valley.

Sediments deposited in layers in flood plains or terrestrial ecosystems can produce many impacts associated with surface waters, ground water. Minerals associated with deposited sediments may depress the pH of surface runoff thereby mobilising heavy metals that can infiltrate into the surrounding subsoil or can be carried away to nearby surface waters. The associated impacts could include substantial pH depression or metals loading to surface waters and/or persistent contamination of ground water sources. In addition, increased velocities and volumes can lead to downstream flooding.

3.3. Impacts of tailing ponds, waste rock, heap leach, and dump leach facilities

The impacts of wet tailings impoundments, waste rock, heap leach, and dump leach facilities on water quality can be severe. These impacts include contamination of groundwater beneath these facilities and surface waters.

Toxic substances can leach from these facilities, percolate through the ground, and contaminate groundwater, especially if the bottoms of these facilities are not fitted with an impermeable liner.

Contaminants could be transported from the tailings impoundment predominantly through the ground water system or through overflow. The mechanisms affecting the transport of a pollutant through ground water system are advective, dispersive and diffusive fluxes, solid-solute interactions and various chemical reactions decay phenomena.

During periods of heavy rain, more water may enter a tailings impoundment than it has the capacity to contain, necessitating the release of tailings impoundment effluent. Since this effluent can contain toxic substances, the release of this effluent can seriously degrade water quality of surrounding rivers and streams, especially if the effluent is not treated prior to discharge.

3.4. Impacts of mine dewatering

When an open pit intersects the water table, groundwater flows into the open pit. The mining companies must pump and discharge this water to another location.
Mine water is produced when the water table is higher than the underground mining workings or the depths of an open pit surface mine.
When this occurs, the water must be pumped out of the mine. Alternatively, water may be pumped from wells surrounding the mine to create a cone of depression in the ground water table, thereby reducing infiltration. When the mine is operational, mine water must be continually removed from the mine to facilitate the removal of the ore.
Impacts from ground water drawdown may include:

- Reduction or elimination of surface water flows
- Degradation of surface water quality and beneficial uses
- Reduced or eliminated production in domestic supply wells
- Water quality/quantity problems associated with discharge of the pumped ground water back into surface waters downstream from the dewatered area.

While dewatering is occurring, discharge of the pumped water, after an appropriate treatment it can be often used to mitigate adverse effects on surface waters.
However, when dewatering ceases, the cones of depression may take many decades to recharge and may continue to reduce surface flows.

Regarding to the database of the Goan State Pollution Control Board (GSPCB), the nearest rivers to mines like Khandepar's river (in Codli) have, on average, a pH from 6 to 9. Although this interval is legally permitted, usually thee values are closer to 6. Moreover, during the Monsoon season, the pH decrease until 5 or 5.5, namely that there is an acidification of the water bodies. One hand, the water excess provokes the releasing of the heavy metals. On the other hand, the contention barriers of waste water from mines. Hence, the contaminated water flows to the river and the groundwater, polluting the aquifers.

In brief, It is important to be noted that the mining and associated activities changes in ground water flow patterns, lowering of water table, changes in hydrodynamic conditions of river/underground recharge basins, reduction in volumes of subsurface discharge to water bodies/rivers, disruption and diversion of water courses/drainages pattern, contamination of water bodies, affecting the yield of water from bore wells and dug wells. Another consequence directly linked to water pollution is the deterioration of soil quality. If soil quality deteriorates, the agricultural productivity of the land decreases.

Therefore, it is necessary to plan the mining and associated activities in such a manner that their impacts on the water regime are minimized.

4. Impacts and degradation of land

The Guidebook for Evaluating Mining Project EIAs, conducted by Environmental Law Alliance Worldwide (ELAW) in 2010, explains the following land impacts caused by mining.

Mining is a temporary land use of the area. Due to excavations for mining and allied activities soil sequences get disturbed. Furthermore, land is required not only for the mine excavation, also is use for beneficiation plant, ore handling and dispatch units, waste dumps, tailing ponds etc.

Due to loosening of the ground natural compactness suffers deterioration and as a result erosion takes place especially where differential topography and high rainfall exist.

Therefore, during mining and post-mining, the major associated land impacts are soil-erosion, loss of top soil, creation of waste dumps and voids, disposal of wastes, deforestation etc.

The iron ores are buried under a layer of ordinary soil or rock (called 'overburden' or 'waste rock') that must be moved or excavated to allow access to the metallic ore deposit. For this reason, the topsoil in the active mining area gets adversely affected.

The soil quality of the surrounding area is also likely to get affected due to siltation and run off from waste dumps. If the mine drainage is acidic and containing toxic constituents, not adequately treated when discharged to nearby land would affect the soil quality adversely.

The pit configuration is planned in such a way that the overall pit slopes remains at 30º or less with the horizontal. Dumps are typically steep with slopes greater than 30º and height of 30-50 Mts. Especially in hill-slope areas where excavations/pits are done for mining not only damage the area excavated, but also affect the embankments slope, causing landslides, the destabilization of slopes.

III. Highlights

Iron ore deposits have been found in Goa because of the singular Goa's geology and concretely the lateritization process due to a favorable geomorphological environment, relative tectonic stability and favorable climatic conditions (tropical maritime and monsoon type) with a high annual rainfall and humidity. Concretely, the 70 % of the Goan area is formed by laterites (residual rock layers).

Iron mining activity generates harmful damages on abiotic environment. The extraction of iron ore causes degradation and pollution of soil, water and air. Consequently, the biotic environment and society are also affected by mining.

The wells are going dry because of the pumped water under the water table to extract the iron ore. The mining activities contribute to soil erosion, loss fertility and compaction. Also, the topsoil is removed.

The monsoon season increase the damages due to mining activity to the physical environment. The heavy rainfall produces surface runoff which encourages the mobilization of heavy metals and silts to the fields and rivers.

CHAPTER II

BIOTIC ENVIRONMENT

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Ecozones, Fauna, Flora, Ecosystem, Western Ghats, Endemic species, Protected areas, Biodiversity loss, Deforestation.

INTRODUCTION

Goa is famous as an international and national tourist destination for its paradisiacal beaches. But certainly, this small Indian state is characterized by having a complex ecological mosaic with high biological value zones. However, few kilometers from the coastal area, hidden from the tourist eyes, an iron ore mining belt extends from north to south destroying the natural environment of Goa.

The aim of this second chapter is to analyze how iron mining affects the biotic environment of Goa. Concretely, it is intended to evaluate the impacts to fauna and flora populations and to the entire ecosystem due to the main pressures generated by iron mining activity.

To achieve these objectives, first it has been necessary to understand the existing biotic environment of Goa. For this reason, the main ecozones of the state have been generally described. Also, the most common Goan flora and fauna and the protected areas have been identified. From that biological introduction, by using superimposing mapping, mining activity has been related with the ecological context, in order to locate the affected areas. This has allowed that, in third section, the major impacts that mining activity causes on Goan biotic environment have been assessed.

I. DIAGNOSIS

1. Overview of the biotic environment of Goa

The biotic environment comprises living organisms which interact that each other and their abiotic environment. All the species in an ecosystem have a big role. This interaction has made Earth a unique habitable place for humans. Biodiversity sustains human livelihoods and life itself and is also the basis of innumerable environmental services that keep humankind and the natural environment alive. According to Millennium Ecosystem Assessment, biodiversity contributes directly (through provisioning, regulating, and cultural ecosystem services) and indirectly (through supporting ecosystem services) to many constituents of human well-being (Millennium Ecosystem Assessment, 2005).

For historical reasons, the region remained relatively underdeveloped until fairly recently (Kotka, 2010). For this reason and for the abiotic characteristics, Goa has an amazing diversity of endemic species, habitats and ecosystems.

1.1. Ecozones

In Goa there are four main ecozones, distributed in three different regions, West, Central and Coastal, which are conditioned by the abiotic environment previously described.

i. The mountainous region of the **Western Ghats** or the Sahyadris, in the east.
ii. The **plateaus** in its central part.
iii. The **alluvial lowlands**
iv. The **coastal ecosystem**

Each region has its own biological characteristics, which make them different from the others; however, each one is interrelated with the rest in a complex way, so that, a change in one region, has a direct effect on the others.

i. <u>The Western Ghats</u>

The Western Ghats, or the Sahyadris, are a major mountain range, which runs 1600 km from north to south, parallels to the west coast of the Indian peninsula trough the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. These mountains cover an area about 140,000 sq. km (WHC, 2009). The Western Ghats are the most representative non-equatorial tropical evergreen forests in the world (Gadgil, 2011). Although they receive a vast amount of monsoonal rain, between 1,500 mm and 7,500 mm annual, Western Ghats' forests are not rainforests in the strictest sense, because the rain is not steadily and predictable through the year (Pai, 2002). For this reason, they cannot be compared with Amazonian jungles. The rainfall monsoonal pattern is not constant through the Western Ghats (N-S), the dry season in the north is longer than in the south, which is the main characteristic to take into account to understand the variations in the flora composition along the Ghats. In general, there are four dominant forest types, directly related to the temperature and rainfall regimes: wet evergreen, dry evergreen, moist deciduous and dry deciduous.

The Western Ghats are divided in three parts: the Northern part is from river Tapti to Goa, the Central part is between Goa and Nilgiris mountains and the Southern part of the Western Ghats occurs in South of the Palghat Gap (Joshi and Janarthanam, 2004).

The Western Ghats in Goa cover about 600 sq. km, which means 16% of the total area of the State (Alvares, 2002). This represents 2% of the Western Ghats (GSCST, 2005). Along the entire Ghats zone, the widest forest zone is around Goa and the surroundings of Karnataka, because the rainfalls in this zone are relatively high (3000-5000 mm/yr) and the elevation is lower in comparison with the other regions (GSPCB, 2007). Thus, the climatic changes due to variations in dry months influence in the formation of ecological mosaics, which means a high biological diversity in Goa.

Flora and Fauna

The lower zones of the Western Ghats in Goa, below 500 m MASL, are covered by moist deciduous forest. On the other hand, the vegetation along the upper Ghats corresponds to transition from semi-evergreen forest to wet evergreen forest in deep gorges and depressions (Forest Dept, 2010 and Govindarajan, 1974).

A significant characteristic of the Western Ghats is their high level of biological diversity and endemism. For this reason, in 1992, the Western Ghats were told to be one of 25 Biological Hotspots on the World by the United Nations Environment Program. However, in July 2012 this mountain chain was recognized as one the 8 Hottest Hotspots of biological diversity along with Sri Lanka. (UNESCO-WHC, 2012). The high degree one of the endemism in the Western Ghats is due to the isolation and the permanent dry climatic conditions in the surrounding areas (Pai, 2005).

In terms of plant diversity, as it is shown in table 2.1., in Western Ghats approximately 5,000 species of flowering plants are found. From that amount of species, about 1,700 (35%) are endemic. As an example, the 50% of evergreen species are endemic to Western Ghats. However, the original remaining forest is about 23% of the total area (Gadgil, 2011 and WHC, 2009).

TABLE 2.1: SPECIES OF VASCULAR PLANTS

Species	India	Western Ghats
Vascular plants	5,000	1,700
Evergreen tress	650	352
Orchids	267	130
Mosses	682	190
Liverworts	280	120

Source: UICN, Gadgil and own elaboration

In Goan Western Ghats it is very frequent to find *Holigarna arnottiana*, *H. ferrugiana*, *Saraca indica*, *S. asoca*, *Calophyllum inophyllum*, *Hopea ponga* and *Hydrocarpus pentandra*, which are endemic of South-west India. In addition, in a restricted zone in Goa, it is possible to find *Myristica malabarica*, a threatened endemic species of Western Ghats (Kotkar, 2010).

On the other hand, as it is shown in table 2.2., vertebrate diversity and endemism rate is very high, too.

TABLE 2.3: VERTEBRATE SPECIES OF WESTERN GHATS

Vertebrate class	Species in Western Ghats	Species Endemic to Western Ghats	Globally Endangered Species
Mammals	139	17	31
Birds	508	17	15
Reptiles	157	97	5
Amphibians	217	197	43
Fish	218	188	1
Total	**1271**	**366**	**95**

Source: WHC and own elaboration

In Western Ghats, 1,271 species of vertebrates have been reported and about 29% of them are endemic. Some of the most important endemic mammals endangered are lion-tailed macaques (*Macaca silenus*), Nilgiri tahr (*Nilgiritragus hylocrius*), Malabar civet (*Viverra civettina*), Asian elephant (*Elephas maximus*), Tiger (*Panthera tigris*), Asiatic wild dog (*Cuon alpinus*). Regarding to birds, species such as Vultures (*Gyps bengalensis* and *G. indicus*) and Great hornbill (*Buceros bicornis*) are also threatened. As it can be observed in table 2.2., the highest levels of vertebrate endemism within Western Ghats are among amphibians, reptiles and fishes.

In contrast, the knowledge of invertebrate diversity is lower in comparison with the vertebrates. In WGEEP Report is specified that there are 350 (20% endemic) species of ants, 330 (11% endemic) species of butterflies, 174 (40% endemic) species of dragonflies and damselflies, and 269 (76% endemic) species of mollusks (land snails) that have been studied in the Western Ghats (Gadgil, 2011).

At least, 325 globally threatened flora and vertebrate fauna species are found in Western Ghats, 129 from them are classified as Vulnerable, 145 as Endangered and 51 as Critically Endangered.

In Goa there are endemic vertebrate fauna species of the Western Ghats, as it specified in table 2.3.

TABLE 2.3. DISTRIBUTION OF ENDEMIC VERTEBRATES IN THE WESTERN GHATS

States	Gujarat	Maharashtra	Goa	Karnataka	Tamil Nadu	Kerala	Western Ghats (2005)
Vertebrates species	**11**	**72**	**47**	**161**	**187**	**236**	**340**
Percent	3.0%	21.0%	14.0%	47.0%	55.0%	70.0%	
State Area (sq. km)	196,024	308,144	3,702	191,791	136,034	38,863	
Density (endemic sp /sq. km)	**5.61E-05**	**2.34E-02**	**1.27E-02**	**8.39E-04**	**1.37E-03**	**6.07-03**	

Source: Pai and own elaboration

Goa is the smallest state from which comprise the Western Ghats. However, it has the higher density of endemic vertebrates, 0.013 endemic species per sq. km. In contrast, Kerala is the state with the biggest richness of endemic species, with about the 70%, but there endemic density is minor. So, in Kerala endemic species are more widely distributed. It is important to remark that in the southern states (Karnataka, Kerala and Tamil Nadu) there are observed more endemic species in comparison with northern states, which are drier than South Western Ghats.

Comparing table 2.2. with 2.3., can be observed differences in the total number of endemic species recorded. The reason of this is that many species still remain to be discovered or classified correctly. Especially with regard to invertebrates and plants, there is still needed a lot of investigation in this biologically rich area. For example, in September 2011, the Hindu newspaper published the discovery of 12 new frog species in the Western Ghats (The Hindu, 2013).

Ecosystem Services

The Western Ghats are very important for their biological value as it is described previously. Nevertheless, Western Ghats form a complex ecosystem that leads ecosystem services of which human obtain profit (Millennium Ecosystem Assessment, 2005). The principal services provided by this ecosystem are, on one hand, regulation services by modulating climate, the water flow and the groundwater recharge.

On the other hand, the Western Ghats provide food, fresh water, wood, fibers, biochemical products, genetic resources and hydroelectrically energy.

Moreover, they lead supporting services by primary production of plants and also, they provide nutrients to marine ecosystem and they add fertility to river valley and delta soil.

Additionally, there are cultural services related with spirituality and religious, education, investigation, recreation, ecotourism, aesthetic values and cultural heritage.

II. <u>The plateaus</u>

The central portion of Goa, between the Western Ghats and the coastal lands, is composed largely from lateritic rock plateaus. They are relatively flat open sections of highlands, ranging heights from 30 m to 100 m. These formations are a characteristic feature of Goa (Alvares, 2002). Plateaus are fairly level at the top but in many areas are deeply cut into gullies, with sharp rims and escarpments slopes towards the plain below them.

Flora and fauna

In general, plateaus have limited vegetation in form of herbs, shrubs and trees. The common vegetation on the top of the plateaus corresponds to different species of scrubs and clumps of grass, due to the thin layer of soil. Instead, the scarp faces and the hollows of the gullies are covered by more intense vegetation, including sparse strands of dry deciduous forest, such as *Carissa congesta*, *Hollarrhena pubescens* and *Lantana cama*. A*nacardium occidentale* (cashew) plantations can be found as well (Goa Forest Department, 2010).

There are transformed slopes into terraced orchard cultivation following the *kulagar* pattern, typical of this part of Goa. This has allowed to increase soil fertility and to use these areas as cashew plantation zones (Gomes, 2002).

The gullies have numerous springs which feed the rivers down below. For this reason, at the base of these tablelands there are rich and fertile orchards.

Earlier floristic surveys revealed that in Goan plateaus there are the largest number of endemic plant species of the Western Ghats, especially herbs (Joshi and Janarthanam 2004). So, open areas with herbaceous vegetation and grasses, many of them being endemic, are characteristic features of the Goan lateritic plateau.

These open areas are important for bird population as they provide better visibility for vigilance from their predators and free movement for hunting. However, no extended studies have been done on the fauna of this region (Desai and Shanbhag, 2012).

Due to their dry barren appearance, which increases during the drier months (Desai and Shanbhag, 2012), plateaus are some of the highly neglected habitats and are often considered as wastelands. Most of them are already ecologically degraded, without any prior serious environmental impact assessment.

Ecological services

Most plateau areas in Goa accomplish important ecological and social functions. On one hand, their low areas are crop zones due to the numerous springs that emerge after the rainwater and then seep into the ground. On the other hand, plateaus are used as common pastures for animals and cattle of *dhangars* and farmers.

Degradation

Any activity on the plateau tops can produce toxic effluents and be hazardous. The effluents may leach into the valleys below and pollute springs, rivers and other water bodies.

On many of these plateaus, the laterite rock is nearest to the surface and it is rich in iron and manganese ores. For these reason, the plateaus have become the scene of large-scale open-cast mining (Alvares, 2002). About 80% of the industrial complexes have been located on the plateaus by the Regional Plan for Goa, dispersing industry to the hinterlands because they are considered as bare open spaces bereft of vegetation.

III. Alluvial lowlands

The alluvial lowland of Goa are the stretches of land bordering the rivers where is deposited the eroded material washed down from the higher levels of the Western Ghats. The major fluvial basins of alluvial formations are those of the Mandovi and the Zuari Rivers, which together constitute the major alluvial deposits, considered as lifeline of Goa'n economy (GSCST, 2005). Trough the course of these rivers an intricate system of wetlands, marshes and cultivate paddy fields are found, interconnected by canals, inland lakes, bays, lagoons and creeks governed by regular tides. There are other major riverine plains of Chapora, Mapusa, Kushavati and Sal rivers. "This area is the most fertile with an uneven character of the entire Konkan coastline" (Gomes, 2002). The high productivity is attributed to the *khazan*, which are saline flood plains in Goa's tidal estuaries, which have been reclaimed over centuries with an intricate system of dykes and sluice gates. They protect the lands from the ocean tides and take advantge from them (Alvares, 2002).

Flora and Fauna

These fertile plains are the main cultivation areas of rice paddy, vegetable crops and fruit-bearing trees, such as coconut, mango and jackfruit (Gomes, 2002).

As it has been introduced previously, beside the rivers, there are natural and man-made wetlands, which have been used to irrigate the paddy cultivations. The wetlands are areas rich in nutrients due to the organic matter resulting of the decomposition of the residual stumps of paddy remaining in the lake. That fact leads to find a high diversity of flora and fauna, especially birds.

The vegetation of these water bodies comprises hydrophytic species, like *Hydrilla verticillata*, *Utricularia aurea* and *Nymphoides sp*. These varied and abundant vegetation in turn sustains a large planktonic and benthic macro-invertebrate populations and, consequently, sufficient abundance of fish. The result of these facts is that the wetlands provide the ideal conditions to shelter a variety of birds, specially, waterfowl, such as herbivorous ducks, insectivorous rails and benthivorous waders.
A total of 163 species of birds, which the migrants alone contribute 55 species, have been observed in and around the wetlands (Alvares, 2002). The Carambolim Lake, Pilar Lake and Santa Monica Lake are the best representatives Goan wetlands.

Ecological services
As already mentioned, the alluvial lowlands of Goa are characterized by their high fertility. This allows cultivating various plantations, which have economic value such as coconut and rice.

More concretely, wetlands are important ecological areas for the amount of biota, especially birds, which depend of them for feeding and breeding.
Aside from provisioning services, wetlands can purify water (Millennium Ecosystem Assessment, 2005) and also grant regulating services by acting as water storage reducing the threat of inundation of runoff from rivers rise during the raining season. They also can be used for gradually release the water and provide valuable fishing grounds.

Degradation
One of the main threats for the wetlands on the alluvial plains in Goa is the siltation caused by runoff of mining dumps and tailing points (Alvares and Saha, 2008). Also, they can be affected by weed infestation, human interference and all kinds of toxic products of the industries and human wastes. These facts may negatively impact to the biotic components of the area.

IV. <u>Coastal ecosystem</u>

The Goan coastal ecosystem along 105 km, is characterized by combination of beaches, rocky shores and headlands. More than 7 km of this coast, comprise sandy beaches including those within estuaries (GSCST, 2005).

It is important to point out, that the coastal ecosystem of Goa has two zones: the open coastal area exposed directly to the sea and the coastal plains and estuarine areas, which is the region analyzed in this study.

Estuarine region
Being a unique characteristic of Goa, its coastal system is intimately connected with the catchment areas of tidal rivers and streams, forming estuarine areas. These rivers, apart from being a water sources, as it has been said previously, contain eroded materials from Western Ghats that maintain the coastal topography

and ecosystem. This influence is so important that the Coastal Regulation Zone extends up to 40 km upstream of the major rivers (Alvares, 2002).

There are seven major dynamic estuarine rivers that traverse the coastal zone of Goa. All the rivers and the backwaters in the hinterland are governed by regular tides (GSCST, 2005). The main channels of these estuaries are from Mandovi and Zuari rivers. In these estuaries is located mangrove habitat, which is an important part of the costal ecosystem.

Mangrove forest

Mangrove habitat is formed by salt tolerant plants occupying the intertidal zone near the mouths of freshwater streams of the coast, usually growing between high tide and mean sea level. It represents a typical tropical and subtropical estuarine ecosystem, which is the major specialized ecosystem on the west of coast of India. India has approximately 315,000 ha of mangrove out from which about 65,000 ha are along the west coast (GSCST, 2005).

Mandovi and the Zuari form the largest estuarine complex that covers 2000 ha. In Goa mangroves cover about 0.5% of the state (Alvares, 2002).

Mangrove is considered to be the most productive and complex ecosystem characterized by the accumulation of clayish mud and fine silt deposits (ENVIS, 2008). The ambience being rich in organic production and nutrients has a high biodiversity that forms various biotic communities with a complex food chain.

- Flora and Fauna

More than 59 species of mangroves tree have been studied all over the world, 45 of this species are found in India. In Goa there are 12 of these species. The Goan mangroves are dominated by the following tree species: *Rhizophora mucronata*, *Bruguiera conjugata*, *Sonneratia apetala, Aegiceras majus* and *Avicennia officinalis*. There is *Kandelia candel*, a rare species that is on the verge extinction worldwide, which is found in plenty in Mandovi, Mapusa and Zuari rivers (Alvares, 2002 and GSCST, 2005). Despite, *Bruguiera gymnorhiza* is rarely seen and can be considered as an endangered species from the Goan coast. There is an associated flora with mangroves, such as *Derris heterophylla*, *Clerodendron inerm*, *Acrostichum aureum*, which are tolerant to high salinity levels (Alvares, 2002).

The major flora species exhibits a number of morphological and anatomical adaptations and physiological characteristics which permit them to flourish under the special conditions of salinity and periodic tidal inundation. The most important characteristic and clearly visible is the aerial root system, which anchor the plants, but also are the main organs for breathing, especially during the high tide, because the mangrove mud tends to be anaerobic (Rana, 1998).

As it has been introduced, mangroves are a complex ecosystem, where there are a lot of species of animals, aquatic and terrestrial, vertically and horizontally distributed along the swamp. The commonest epifauna forms are gastropods mollusk, such as snails and whelks; bivalve mollusk like oysters; crustaceans, represented by a variety of crabs, shrimps, mud lobsters and barnacles; and fishes of which the commonest form is the mud skipper (family Gobiidae). In contrast, the infauna forms are mainly represented by nematodes and polychaetes. Moreover, higher vertebrate fauna is represented by marsh crocodile, fish cat, otters, jackals, turtles, flying foxes, a lot of bird like small blue Kingfisher and others.

Mangroves in Goa are also a haven for migratory birds, which can be seen in plenty at any point of time, such as *Anas acuta* (pintals) or *Ardeola striatus* (heron).

There are important commercial animals, such as the young stages of shrimps and fishes like the mullets, which use the mangrove ecosystem as shelter and nursery grounds.

- Ecological services

Mangroves provide a wide range of services and benefits to the livelihood of coastal people and also have immense ecological and economic significance. On an ecological view, mangrove ecosystem acts as buffer zone between the land and sea. It protects the coast against erosion (Millennium Ecosystem Assessment, 2005). Also, it purifies the water by absorbing impurities and harmful heavy metals.

In addition to providing free services, mangrove forest plays an important role in economic activities. They are also a source of a vast range of wood and non-wood forest products including timber, fuel wood, honey, etc. People in Goa are making use of mangroves by protecting them as a nursery ground for various fish and crab species, which forms a part of their daily food (Sahay, 2007). Mangrove forests are also important in terms of aesthetics and tourism and it provides opportunities for education and scientific research.

- Deterioration

Mangrove forests are one of the world's most threatened tropical ecosystems (ENVIS, 2008). The main threats of the area are mainly due to population pressure in and around the mangrove belts. Another important anthropogenic impact is the use of dragnets on fishing that uproots the young regenerations and plantations. Furthermore, some mangrove areas are over harvested. Moreover, qualitative and quantitative changes in the amount of water that mangrove reaches the forest causes negative consequences to the ecosystem. Besides, there are natural hazards that affect the mangroves, such as barnacle infestation of the plantations (generally *Rhizophora mucronata*), insects or weed pests and damages to young seedling due to browsing and trampling by wildlife (ENVIS, 2008).

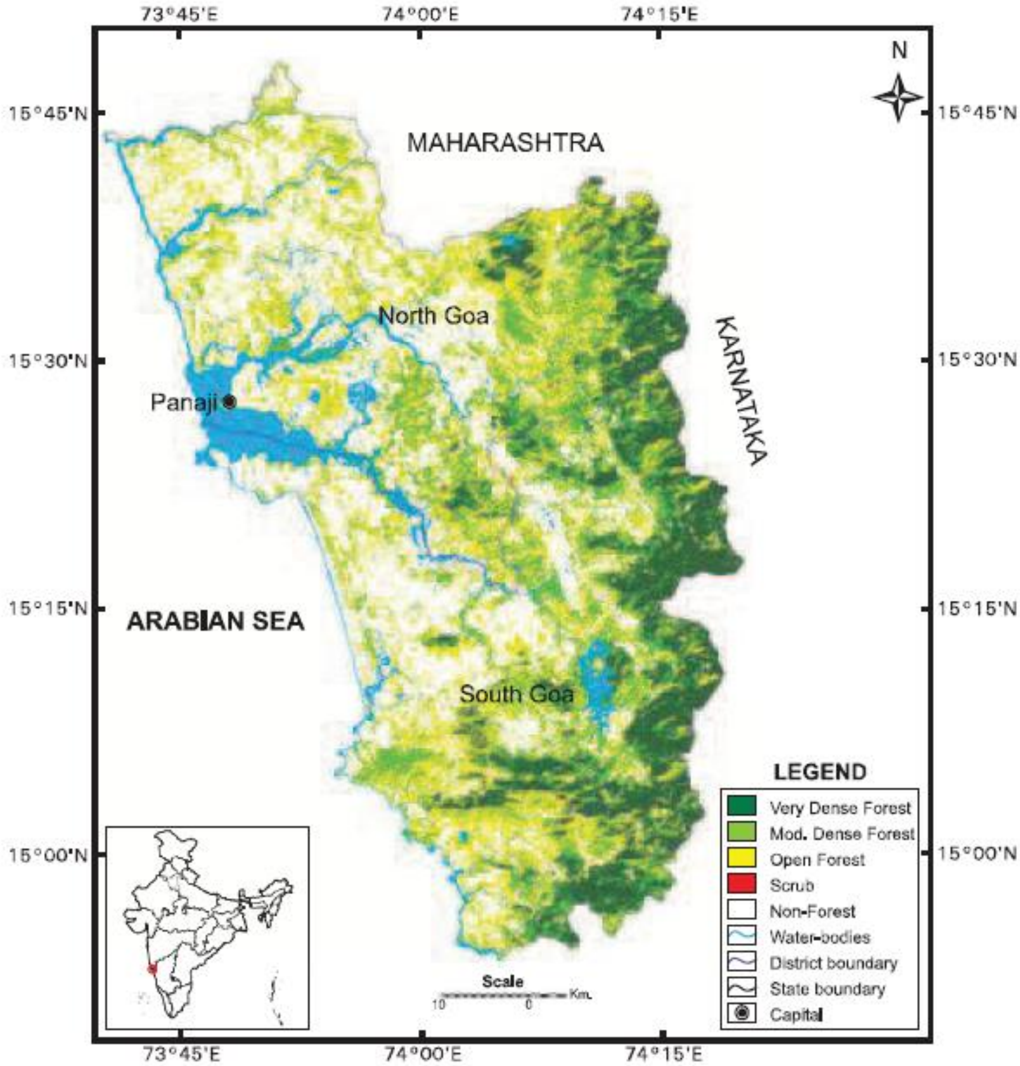
It is essential good management strategies to conserve the biodiversity in the mangrove ecosystem for their special ecological value. With this, the supply of the ecosystem services will be ensured, permitting the humankind to take profit. So, it is necessary to maintain the environmental stability and ecological balance in the region to conserve the biodiversity and the genetic resources. In Goa there is the Dr. Salim Ali Bird Sanctuary, which is the only one representing the state's vital mangrove area.

1.2. Forest and flora of Goa

The total forest area in Goa is 1,424 sq. km, which covers about the 38% of the total geographical area. Concretely, 1,224 sq. km is Government Forest and 200 sq. km are private forests (Goa Forest Dept, 2010 and Forest Survey of India, 2011). Since there is a substantial area under a large tract under cashew, mango, coconut, etc. plantations, the total forest and fruit trees plantations covers about 56.6% of the geographic area of the State (Government of Goa, 2013).

In map 2.1, the forest is classified according to its canopy density. So, about the 14% is very dense forest, corresponding basically to the Western Ghats; the 15% is moderately dense forest and the 30% is open forest. In the remaining 40% there is no forest (Forest Survey of India, 2011).

MAP 2.1: FOREST COVER OF GOA



Source: Forest Survey of India

Diversity in vegetation types is conditioned by the abiotic features of the place, particularly, it is closely related with temperature and rainfall regimes, which depends on the altitude (Smith and Smith, 2005). Thus, the dominant Goan vegetation is typically tropical variety (Gomes, 2002).

As per Champion and Seth Classification of Forest types of India (1968), in Goa there are two main types of forest, the moist deciduous forest and the wet evergreen forest, which are typical of the Western Ghats. On the one hand, moist deciduous forest [3B/C2] is the dominant vegetation type in Goa (Alvares, 2002), covering more than the half of the forest areas (Goa Forest Dept., 2010) in the rainfall zone from 2.500 mm to 3.500 mm (Pai, 2005), which is placed along upper plateau hills and lowlands of Western Ghats. Moist deciduous trees are tall and start to loss their leaves during the dry season and the canopy remains leafless between February and May, until the pre-monsoon rainfall starts. This is a mechanism to avoid loss of water through transpiration due to dryness. The falling leaves are a great contribution of soil organic matter, so the forest floor is full of vegetal growth. Predominant species of moist deciduous trees in Goa are *Terminalia crenulata, T. belerica, T. paniculata, Lagerstroemia parviflora, Adina cordifolia, Albizia lebbeck, A. procera,* *Mitragyna parvifolia, Holoptelia integrifolia, Trewia nudiflora, Dillenia pentagyna, Semicarpus anacardium, Mallotus philippensis and Stereospermum colais* (Goa Forest Dept. 2010; Alvares, 2002; Govindarajan, 1974 and TERI, 2007). Portions of forest are cleared to convert it into plantations of different species such as teak, sal, eucalyptus, mango, bamboo and rosewood (Gomes, 2002).

On the other hand, in deep gorges and depressions along the upper Ghats, where the rainfall exceeds 2,500 mm to 5,000 mm (Pai, 2005), occurs the evergreen forest. However, there is a transitional stage where is located the semi-evergreen forest [2A/C2] which is a mixture of vegetal species of wet evergreen and moist deciduous type. The forest is dense and there is a large variety of tall trees with thick trunks and lighter canopy in comparison with evergreen forest trees. Besides, there is lateritic semi-evergreen forest [2 E4] found on shallow dry lateritic soils (containing 90-95% of iron, manganese, aluminum and titanium oxides) and is characterized by the dominant presence of *Xylia xylocarpa* (TERI, 2007).

Instead, the wet evergreen forest [1A/C4] is characterized by heavy species density. The top canopy is almost unbroken comprised of tall trees, heights of 45m or even more. The leaves of trees are small and narrow to minimize moisture loss through evaporation. Instead, the lower growing plants have larger leaves in order to maximize the benefit of the little light that manages to penetrate. Trees always have leaves, as they shed them at a slow and steady rate throughout the year, which results in continuous decay and decomposition of organic matter on the forest floor (TERI, 2007). The main species found in Goa are *Calophyllum calaba*, *Garcinia gummi-gutta*, *Canarium strictum*, *Lophopetalum wightianum*, *Myristica spp.*, *Knema attenuata*, *Chroisophyllum acuminata, Palaquium ellipticum*, *Artocarpus gomezian*s, *Diospyrus ebenum*, *Mangifera indica*, *Persea Macrantha*, *Mimusops elengi*, *Hopea ponga*, *Olea dioica*, *Hydnocarpus pentendra*, *Syzygium cumini*, *Holigarna arnotiana*, *Litsea coriacea*, *Mallotus philipprnsis* and *Ficus spp* (Goa Forest Dept. 2010; Alvares, 2002 and Govindarajan, 1974).

The common and dominant tree species widely distributed along Goa are *Terminalia tomentosa*, *T. paniculata* and *Xylia xylocarpa* (Kotkar, 2010).

Goa is also dominated by plateau vegetation (Joshi and Janarthanam, 2004) formed by open scrub jungle [5.E7], which is mainly composed of widely found dry deciduous elements such as *Carissa congesta*, *Lantana camara*, *Hollarrhena pubescens* and *Anacardium occidentale* (Goa Forest Dept. 2010).

In Goa has been found a total of 1,512 species of plants (Alvares, 2002). A floristic survey of endemic plants of the Western Ghats in Goa concluded that exist 113 endemic flora species (Joshi and Janarthanam, 2004). The family Poaceae has 13 species, being the largest number of endemic species, followed by Acanthaceae, Rubiaceae, Fabaceae and Orchidaceae families. The herbs are the dominant life-form type (58%), followed by trees (20.35%), shrubs (14.15%) and climbers (7.07%). It is interesting to remark that herbs are predominant in the plateaus, where there is about 36.2% of endemic species. Although Goa only shelters about 2% area of Western Ghats, accounts for 7% of endemic flowering plants of them (Kotkar, 2010).

As it is known, flora and fauna are interrelated, one depends on the other. Specially, animals depend of flora to refuge, to reproduce and to nurture. As example of this strong relation, in Goa there are some tree species such as Ficus, Carya, Erythrina, Butea, Bombax and Lagerstromea that attract 6 to 9 families of birds. One widely distributed tree in Goa is *Mimusops elengi*, which especially attracts green pigeons (Kotkar, 2010). The forest with more heterogeneity in the structure and composition of the vegetation have more species.

1.3. Fauna of Goa

Goa also has richness fauna diversity. Concretely, it is possible to find 1,326 species of animals, some of which are endemic, as it specified in table 2.4. This fact is induced due to Goa is the transitional zone between Northern and Southern Western Ghats, having a combination of characteristics of the two other parts, giving Goa a unique characteristic. In fact, the geographical range of many southern endemic species of Western Ghat begins in Goa (Zoological Survey of India, 2012). Some of the Goan animal species are endangered and have been classified by IUCN. It is important to remark the *Cnemaspis goaensis* (Goan Day Geck), endemic reptilian specie of Goa that is critically endangered.

Some of the most common endangered animals found in Goa are listed in table 2.5. Most of them are distributed on the strip east of Goa, in the Western Ghats, where the forests are dense and there is less urban development. Furthermore, this west area is under protection, becoming a safely corridor between Maharashtra and Karnataka.

It is necessary to take special attention to butterflies as keystone specie. Aside from their special beauty, butterflies are important pollinators, such as bees, and environmental state biomarkers, too. In the Indian subcontinent, about 1,500 species of butterfly have been observed. In contrast, in Goa is possible to find 65 species, such as *Troides minus*, which is the largest butterfly found in India (Alvares, 2002).
The butterflies diversity and richness are indicative of flora diversity of the habitat. They are good biomarkers. Thus, a decline in diversity of butterflies is suggestive of habitat degradation (Manoj, 2004). Also, as it is known, pollination assures the perpetuation of plants. One third of human food is derived from plants pollinated by wild pollinators. Without natural pollination services, yields of crops would decline precipitously and many wild plants would become extinct (Issues in Ecology, 1997).

Butterflies larvae are totally dependent of specific plants. If these plants are eliminated, butterflies are effectively eliminated as well, causing problems to the entire ecosystem. In Goa many butterfly species are lost due to habitat loss and illegal hunting (Alvares, 2002).

TABLE 2.4: FAUNAL DIVERSITY OF GOA

Group	Genera	Species	Endemic	Threatened (UICN categories)
Parasitic Protozoa	11	103	NA	-
Mollusca (Land and Freshwater)	15	25	NA	-
Chilopoda (Centidepe)	4	8	*Cormocephalus dentipes*	-
Cladocera	29	44	*Pleuroxus aduncus bhigawanesis*	-
Isopoda (Land and Marine)	3	7	NA	-
Crabs (Marine and Estuarine)	33	47	NA	-
Anomurans Crabs	4	11	NA	-
Odonata	39	-	*Agriocnemis* pieris, Elatloneura *tetrica*	-
Mantodea	8	9	NA	-
Lepidoptera	141	251	*Troides minos, Papilio dravidarum, Papilio buddha, Cethosia nietneri, Cirrochroa thais, Kallima horsfieldi, Idea malabaria*	13 sp. listed in India Wildlife Protection Act 1972
Arachnida	33	50	*Neoscona molemensis, Lycosa mahabaleshwarensis, Rhene khandalensis*	-
Pisces (Freshwater)	31	58	NA	-
Amphibia	17	28	NA	-
Reptilia	57	100	• Turtles: *Melanochelys trijuga trijuga, Trionyx leithi* • Gekos: *Cnemaspis goaensis**, Hemidactylus maculates, Hemidactylus prashadi***, *Hemidactylus reticulatus* • Skinks: *Mabuya allapallensis, Mabuya trivittata, Riopa lineate, Riopa goaensis,* • Snakes: *Typhlops acutus, Uropeltis ellioti, Uropeltis macrolepsis, Uropeltis ceylanicus, Uropeltis myhendrae, Dendrelaphis grandoculis, Amphiesma beddomei, Amphiesma monticola, Callophis nigrescens, Hypnale hypnale, Trimeresurus gramineus, Trimeresurus malabaricus, Phyton molurus*	60 sp./subsp. listed in India Wildlife Protection Act 1972 7 sp. Threatened 4 sp. Vulnerable *Criticaly endangered ** Endangered
Aves	238	458	*Columba elphinstonii, Psittacula columboides, Ocyceros griseus, Pycnonotus priocephalus, Iole indica, Eumyisas albicaudata, Cyornis pallipes, Garrulax delesserti, Rhopocichla atriceps, Turdoides subrufus, Nectarinia minima, Dendrocitta leugogastra*	14 sp. Threatened
Mammalia	57	83	Rodents: *Anathana ellioti ellioti, Ratufa indica indica, Ratufa indica bengalensis, Funambulus tristiatus*	57 sp. listed in India Wildlife Protection Act 1972
Total	**707**	**1326**	**-**	

NA: Not available

Source: Zoological Survey of India and own elaboration

TABLE 2.5: ENDANGERED COMMON ANIMALS IN GOA

Tiger (*Panthera tigris*)	Flying Lizard (*Draco dussumteri*)
Panther (*Panthera pardus*)	Python (*Phython molurus*)
Leopard Cat (*Felix bengalensis*)	Indian Cobras (*Naja spp.)*
Slender Loris (*Loris tardigradus*)	King Cobra (*Ophiophagus hannah*)
Gaur (*Bos gaurus*)	Russel's Viper (*Vipera ruselli*)
Mouse Deer (*Tragulus meminna*)	Checkered Keelback (*Xenochrophis piscator*)
Pangolin (*Manis crassica udata*)	Rat Snake (*Plyas mucosus*)
Indian Giant Squirrel (*Ratufa indica*)	Peafowl (*Pavo cristatusk*)
Sloth Bear (*Mellersus ursinus*)	Great Indian Hornbill (*Bureros bicornis*)
Bazas (*Aviceda leuphotes*)	Indian Pied Hornbill (*Anthracoceros malabaricus*)
Jackel (*Canis aureus*)	Hill Myna (*Gracula species*)
Jungle Cat (*Fells chaus*)	Frog Mouth (*Batrachostomes species*)
Mongoose (*Herpestes sp.*)	White Bellied Sea Eagle (*Haliaetus leucogaster*)
Malabar Civet (*Viverra civettina*)	Vuhures (*Gyps bengalensis*)
Golden Gacko (*Calodaretly Loides aureus*)	Indian Giant Flying Squirrel (*Petaurista philippensis*)

Source: GSPCB, Alvares and own elaboration

1.4. Protected Areas in Goa

The state of Goa has one National Park (NP), one Bird Sanctuary and five Wildlife Sanctuaries (WLS), as it is listed in table 2.6. The protected areas are under the Wildlife Protection Act, 1972.

According to the India Wildlife Protection Act, 1972, the State Government considers a Sanctuary an area if it is adequate ecological, faunal, floral, geomorphological, natural or zoological significance, for the purpose of protecting, propagating or developing wildlife or its environment. In the act is also specified that "no person shall destroy, exploit or remove any wildlife from a sanctuary or destroy or damage the habitat of any wild animal or deprive any wild animal or its habitat within such sanctuary except under and in accordance with a permit granted by the Chief Wildlife Warden and no such permit shall be granted unless the State Government being satisfied that such destruction, exploitation or removal of wildlife from the sanctuary is necessary for the improvement and better management of wildlife therein authorizes the issue of such permit" (Ministry of Environment & Forest, 1972).

On the other hand, according to the IUCN categories of Protected Areas, a National Park belongs to the category II. "The main objective is protecting functioning ecosystems, but allowing the human visitation and supporting infrastructures. The extractive use is not permitted. National parks are managed in a way that may contribute to local economies with the promotion of educational and recreational tourism without reduce the effectiveness of conservation efforts. Its surrounding areas may be for consumptive or non-consumptive use, but never should to negatively affect for the defense of the protected species and communities" (UNEP-WCMC, 2013).

In contrast, a Wildlife Sanctuary has the category IV, corresponding to a Habitat/Species management area. They "are focused on specific areas of conservation, but in relation to an identifiable species or habitat that requires continuous protection. These protected areas have to be controlled to ensure the maintenance, conservation and restoration of particular species and habitats, possibly by through traditional means and public education. WLS may exist as a fraction of a wider ecosystem or protected area and may require different levels of active protection. As example, some management measures could be: the prevention of poaching, creation of artificial habitats, etc." (UNEP-WCMC, 2013).

TABLE 2.6: PROTECTED AREAS OF GOA

Protected Area	Location (Taluka)	Year Notified	Area in sq. km
Bhagwan Mahavir Sanctuary	Sanguem	1967	133
Cotigao Wildlife Sanctuary	Canacona	1968	87
Bondla Wildlife Sanctuary	Ponda	1969	7,9
Molem National Park *	Sanguem	1978	107
Dr. Salim Ali Bird Sanctuary	Tiswadi	1988	1,78
Madei Wildlife Santuary *	Sattari	1999	209
Netravali Wildlife Sanctuary *	Sanguem	1999	211
Total Protected Area			**756.68 sq. Km**

* Affected by mining

Soure: Alvares, Saha and own elaboration

As it is specified in table 2.6. the total Goan area under protection covers over 756.68 sq. km, about the 20.4% of total geographical area. In particular, the Western Ghats of Goa are almost completely protected by Mollem NP, Bhagwan Mahavir WLS, Cotigao WLS, Bondla WLS, Madei WLS and Netravali WLS. This fact supposes that the entire chain within Goa is under protection. As a result, the whole west zone of Goa is a continuous corridor area from North to South, permitting animals to move freely along the State and also cross to Maharashtra and Karnataka.

Moreover, the Dr. Salim Ali Bird Sanctuary protects a mangrove area along the Mandovi and Zuari rivers and is also important for migration birds. A large colony of critically endangered flying foxes live there and it is possible to see crocodiles, turtles and jackals, too (Alvares, 2002). In theory, there should be no human presence in the sanctuary, but there are 21 villages within 5 km radius. Consequently, it is inevitable some illegal cutting of firewood, and traditional fishing of crabs, fish and bivalves.

In Madai WLS, there is located Wroughtons Free-Tailed Bat (*Otomops broughtoni*), which is a critically endangered species. Additionally, *Myristica malabarica*, a threatened plant species of Western Ghats was restricted to a single habitat which has presence almost exclusively within this WLS (Kasturirangan, 2013).

It is important to remark that Goa was under Portuguese rule for over 400 years till 1961. Meanwhile, the other parts of India, which were ruled by British, studied and documented the flora and fauna of the States through the Imperial Gazetteer of India (established in 1881), the Botanical Survey of India (established in 1887) and the Zoological Survey of India (established in 1916) (Gomes, 2002). As a consequence, flora and fauna of Western was studied by British, but these research institutions could not access and explore Goa. Lately that new species have been discovered in Goa's. Thus, the scope of new biological studies in the region is vast. Meantime, protected areas ensure the conservation of these species that have not been yet discovered.

Sacred Groves

India has a long tradition in protecting nature, considered sacred. Forests have been the lifeline for tribes and other communities for ages, for this reason sacred groves are dedicated to gods or other local deities. Sacred groves ranged from a few hundred square meters to some tens of forest hectares (Pai, 2005). These areas have contributed to the conservation of tropical biodiversity, due to the protection afforded by villagers following rules passed from one generation to another.

The grove has virgin forest in its climax condition, unlike the rest has suffered some human interference. The good consequence is that several species of plants, which have disappeared everywhere else, have been preserved *in situ* (Alvares, 2002).

Unfortunately, even in remaining areas, human interferences are increasing due to commercialization and tourism, which do not have the same respect as locals. Earlier, almost all villages have sacred groves, but nowadays there are only few places where the tradition is still alive.

One of the 55 best preserved sacred groves of Goa is situated in Keri, which lies on a hill slope and covers a large area of 10 hectares. Plants and animals receive absolutely protection in the grove, even during traditional hunting by villagers. This is a valuable example of successful social fencing.

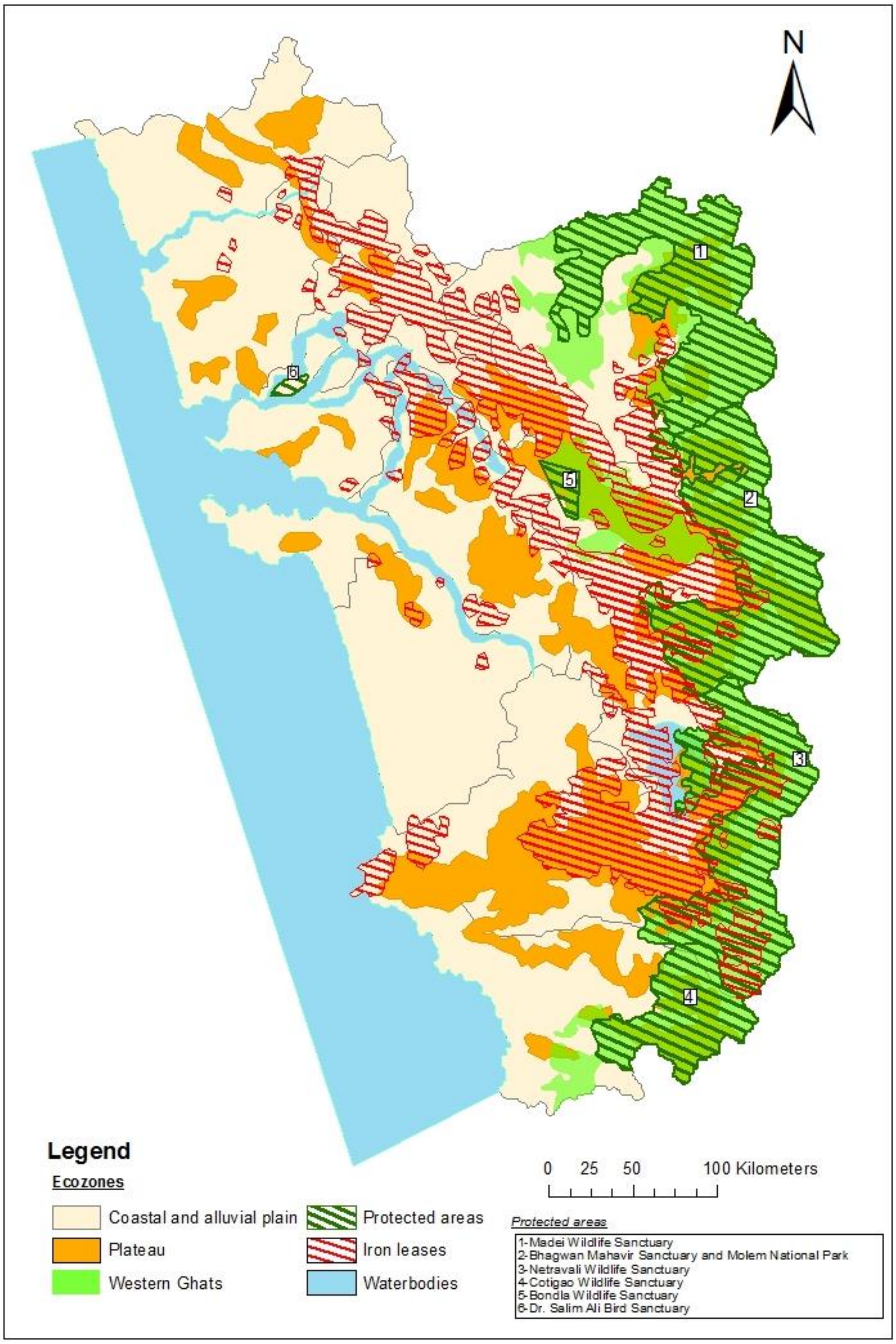
2. Biotic environment in the iron mining context

As it has been introduced in Chapter 1, Goa has a 700 sq. km of iron mining area located in the central-eastern part of the State, as it has been shown in the map 2.2. It is demonstrated that the iron mining belt occupies mostly part of the plateaus and Western Ghats area.

As it has been previously studied, the Western Ghats and plateaus shelter flora and fauna species that are endemic or even threatened of extinction, such as *Myristica malabarica* or *Cnemaspis goaensis*. For this reason, it has been essential create protective measures as five Wildlife Sanctuaries and a National Park to ensure the conservation of these biological important places. However, these instruments to safeguard the biodiversity of Goa and of the Western Ghats are not being sufficient. While mining activity continues to be a business with strong political influence, the effort to protection is decreased, as any mining operation is been done with environmentally conscious. Consequently, severe impacts on flora and fauna are being generated where the mines are located, basically in forest areas of plateaus and Western Ghats.

Dr. Gadgil mentions in the Western Ghats Ecological Experts Panel Report that most of the mining leases in Goa are located in and around WLSs and forest areas. In table 2.7. is specified the distance to WLSs and NP of 162 mining leases.

MAP 2.2: ECOZONES, MINING AREA AND PROTECTED AREAS OF GOA



Source: Llavina Pascual, Xavier

TABLE 2.8: THE DISTANCE OF THE MINING LEASES FROM THE BOUNDARY OF THE NEAREST NP/WLS

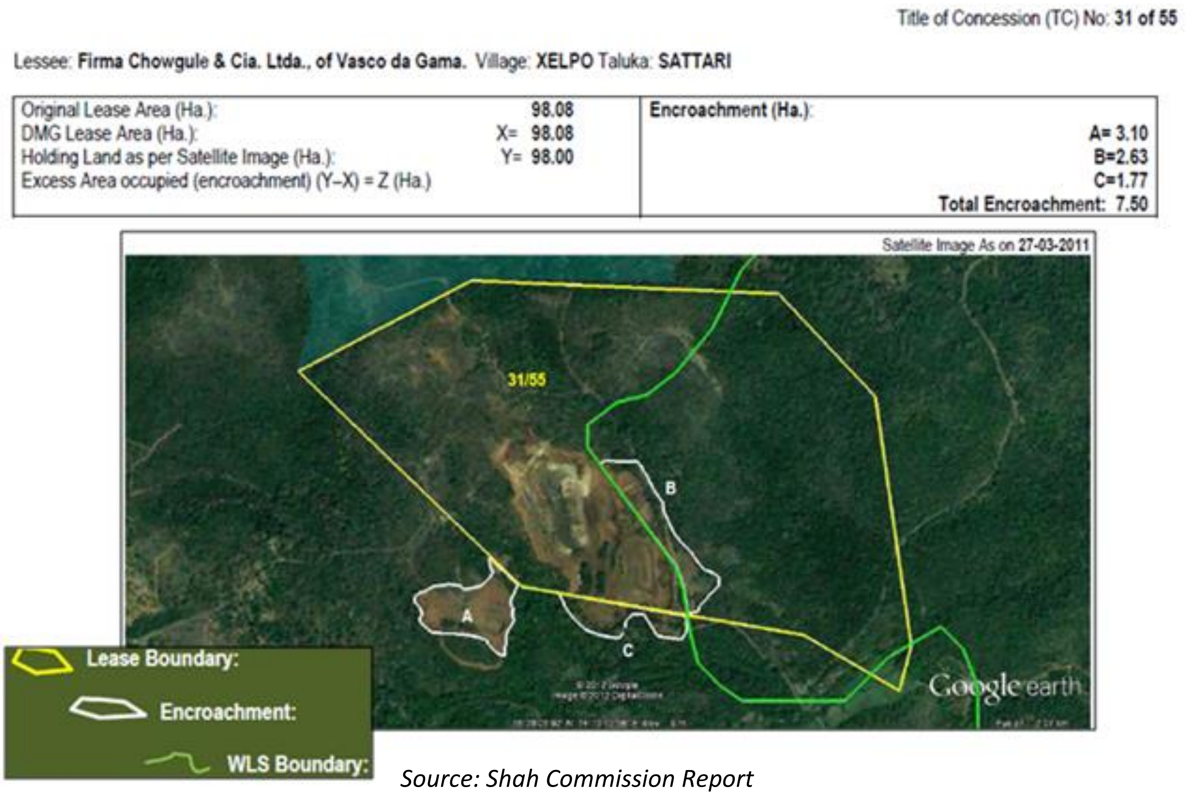
Mining Leases	Working	Non Working	Total
Within or partly Within NP/WLS	7	13	**20**
Within 1 km	23	8	**31**
Between 1 km to 10 km	74	29	**103**
Beyond 10 kms	6	2	**8**
Total	**110**	**54**	**162**

Source: Central Empowered Committee and own elaboration

The most important fact is that 20 mining leases are within or partly within a NP or WLSs, from which 7 are working leases. Also, 23 mining leases are operational within 1 km from the protected areas and 74 are from 1 to 10 km.

In figure 2.1. it is possible to observe a mining lease having its boundaries inside a WLS. There are 3 encroachments out of the lease boundaries: one of them is into the WLS, occupying an area 2.63 ha.

FIGURE 2.1: MINING LEASES PARTLY WITHIN A WILDLIFE SANCTUARY



Source: Shah Commission Report

Defining a protected area does not mean that the natural environment is immune to impacts from the border of the WLS. The reality is that a deep zone is under the influence of degraded areas surrounding it. There is the border effect, especially in forests that are in contact with altered areas by human activity (López, 2004), as in this case of study (Mining activity - Forest). Although the ecosystem is under protection, if its surrounding areas are altered, the perturbation can penetrate into the natural system. The effect of the contact could cause many disturbances very far from the boundary of the protected area, seriously affecting the natural ecosystem.

Since 2002, in Goa there is a polemic to establish a *buffer zone* around WLSs and NP. Government Ministry of Environment and Forest, mining lobby, Supreme Court and activists against mining have discussed which is the best distance, between mining area and protected areas, without any agreement . Nevertheless, in 15th June 2013 the Minister Manohar Parrikar said to media "that Goa may have a 1 km buffer zone" (The Weekender, June 2013). But, in 21st June 2013 the Central and the State authorities were veering to the news "a 2 km buffer zone could be declared in the state around the WLSs" (The Navhind Times, 2013). A buffer zone of 2 km would mean that more than 30 mining lease will have to stop working forever. This fact will enhance the protection of the WLSs and will reduce the border effect, too.

The Molei WLS, Madei WLS and Molem NP are the three protected areas most affected by iron mining activity (Alvares and Saha, 2008). However, as it is showed in map 2.2., in plateaus area there are many mining leases, and some of them are very close to rivers. All rivers come down from the Western Ghats, passing through plateaus and flowing into the Arabian Sea.

It is difficult to exactly calculate how many hectares of forest have been lost for mining activity. The Western Ghats Ecology Experts Panel, from a study conducted by TERI in 1997, indicates a total of 2,500 ha of forest deforestation between 1988 - 1997 (Gadgil, 2011). However, the Regional Planning of Goa-2021 estimates that about 1,110.81 ha have been diverted to mining as the data furnished by the Forest Department (no data was given) (RPG, 2012). It is important to remark that both data are unrelated and there is no coherence between them.

In contrast, in Goa Sweet Lands of Mines is specified that almost 2,000 ha of forest are affected due to mining. The total estimated area under mining activity is over 6,690 ha, occupying 1.8% of the total geographical of Goa (Alvares and Saha, 2008).

No studies to assess the loss in forest have been done since 1997 (Gadgil, 2011). Moreover, the illegal mining, that occupies more forest than allowed in the leases, is not considered anywhere. Therefore, it is currently impossible to determine the amount of forest lost due to mining.

It is necessary to question why this situation is possible in protected areas. Also, it is essential to specify which consequences could have to the biota and to the entire ecosystem in long and short term.

II. Mining effects on the biotic environment

The populations of plants and animals in an ecosystem does not operate independently, they are related and form a community. The community and the physical environment are the ecosystem. An ecosystem is a set of interconnected parts which function as a whole. Therefore, it must be considered that cause an impact on an ecosystem's element can ultimately affect the entire ecosystem.

The most serious environmental conflicts in Goan mining industry revolves around access to mineral reserves in Western Ghats, which are recognized as habitat of significant conservation values and biodiversity richness.

Mining activity has the potential to affect biodiversity throughout the cycle of a project. Set out below are the major pressures and the derived impacts that affect the biotic environment of Goa.

1. Deforestation

The biological impacts associated with mining are primarily related to changes in land use. Deforestation is the major cause of biotic environmental impacts related to mining activity. According to Millennium Ecosystem Assessment classification of main direct pressures, habitat change in tropical forest supposes a very high driver's impact on biodiversity (MA, 2005).

In Goa, deforestation was inevitable as more than 350 sq. km of mining concessions and leases are within forest areas of the Western Ghats (Alvares, 2002). So, the impacts have been very important on the Western Ghats, which it has been mentioned, are one of the global biodiversity hotspot.

A first sight, the resulting situation are big red holes in the middle of forests areas (See annexure 1, Figure 5). However, the problem is more complex, as it is explained below.

Loss of vegetation cover occurs not only in the mined area but also in areas affected by associated activities such as dumping of overburden, deposition of tailings, development of infrastructures for transport and service corridors (railway lines, roads, etc.) and surface facilities (offices, vehicle parks, etc.) (ICCM, 2010).

Clearance of natural vegetation adversely affects the flora and fauna of the areas due to changed environment (ASCI, 2010). Deforestation also generates a domino effect of impacts that are interrelated each other.

Loss of habitat

The main impact that deforestation generates is the loss of habitats. To open a mine, all the existing vegetation is removed directly. This means, on one hand, the destruction of the habitat of all flora and fauna species that lived there. On the other hand, it affects directly to the populations. Obviously, populations of flora die directly due to are grubbed. While some wildlife populations, whether they detected the danger in time, they can migrate to other areas. Small mammals, but mostly reptiles, amphibians and insects are directly affected by the machinery.

It is important to define that the extinction of species begins with local extinction when the local conditions deteriorate or the habitat disappears. Over time, successive local extinctions lead to total extinctions (Smith and Smith, 2005). The most important cause of extinction is habitat destruction or alteration, which is a local phenomenon. Due to the rapid speed of habitat destruction, species do not have enough evolutionary time to adapt to new and changed conditions. Forced to emigrate, individuals find that other habitats are already occupied and face intraspecific or interspecific competition (Begon et al, 1990).

Fragmentation of habitats

Clearance of natural vegetation implies also the fragmentation of biological habitat. Fragmentation results in habitat loss and degradation of ecosystem.
There are differences how the fragmentation impacts to flora and fauna. The affected animal populations are divided into smaller populations in isolated areas, that constrain movements by species (for example, for foraging, breeding, migration and dispersal), remaining without contact with other members of the same species. As a result, populations have less genetic variability, which means that they are less adaptable to environmental changes. Often the survival of local populations depends on migration of new individuals. But as the distance between local populations grows and the size of the local populations is smaller, immigration becomes impossible. When the local population falls below the minimum viable population size, it can be extinguished due simply to random fluctuations in reproductive success (Begon et al, 1990).

Instead, plants populations have to face habitat destruction caused by mining activity. This leads, as it is been said, the massive destruction of whole flora communities, some of which may be very restricted to certain habitats. Unlike animals, plants possess very limited dispersive skills and cannot escape looking more favorable habitats, or cannot quickly adapt to new environmental conditions.

The importance of ecological connectivity amongst habitat patches and species' populations across the landscape is widely recognized. Consequently, fragmentation of habitat into patches of insufficient size may not be able to meet the species' requirements and may also cause loss of connectivity due to reduction in species mobility between supportive habitats (Smith and Smith, 2005).

The fragmentation of the forest area in Goa, not only would suppose an ecological discontinuity for Goan species. It would also affect the biological corridor from North to South of the Western Ghats between Maharashtra and Karnataka.

Loss of biodiversity

As already it has been said, reduction in forest cover and habitat fragmentation have very adverse effects on wildlife. The worst consequence is the loss of organisms, which could be translated in a decrease of populations. This fact becomes a drastic ecologic problem when there are few populations of the same species. As a result, the species would become rare or even endangered almost on the verge of extinction, such as Lion-tailed macaque (*Macaca silenus*), Nilgiri langur (*Trachypithecus johnii*) and Nilgiri tahr (*Nilgiritragus hylocrius*) which are forest endangered species (Alvares, 2002).

To ensure the persistence of a subpopulation in a viable state over the years, it is needed a minimum viable population. This population should be large enough to support random variations of births and deaths, random environmental events, genetic drift, etc.

Migratory species are also affected because they lose the fix site of settlement during his travels. For the survival of migratory species wintering areas are crucial.

In the long term, deforestation without rehabilitation entails a loss of native biodiversity. Because it has been said, the populations tend to disappear, either by migration or reproductive infeasibility.

2. Noise and vibrations

The equipment used in the opencast mines for various purposes including the digging and transport of the overburden and mineral generates continuous noise, while blasting produces impulsive noise. All the noise generated in the mine does not become ambient noise. That cause negative effects on the fauna. The effects of noise are given in the terrestrial and the aquatic environment. Nevertheless, in mining case, the terrestrial animals are most affected, because mining is a terrestrial activity. However, it should be noted that the export of iron is carried out by ship, therefore, mining also generate noise in water in an indirect way.

There are three potential noise impacts on animals: auditory damage, physiological changes and behavioral alterations. These generate direct physical effects to the animal and indirect changes which occur between the animal and its environment.

On one hand, the noise can cause hearing problems. At very high exposures, the animal may lose all or part of auditory sensitivity. This altered the way in which animals communicate, mate and even protect themselves from depredators. Consequently, the operating capacity of animals is reduced, which has little chance of survival.

On the other hand, animals also suffer physiological effects, such as metabolic and hormonal changes, induced by stress. For wildlife, stress reactions are part of survival and a routine occurrence. Stress reactions involve what is commonly referred to as the “fight or flight” response (Nicks, 2012). When this reaction is inappropriate, such as escaping from a noise that is not a threat, impacts begin to occur. Inappropriate reactions deplete unnecessarily an animal's energy resources. Excessive noise has the ability to raise an animal's heart beat speed, and even harms an animal's metabolism. These facts can increase susceptibility to predators, disease, and starvation and decrease the reproduction activity in a wide range of animals.

Noise also causes changes in animal behavior, being the most apparent impact on wildlife. These changes include alterations in habitat locations and migration patterns, and abnormal behavior that can negatively affect the breeding and feeding patterns of some animals. This is one of the reasons why certain species have become extinct.

Noise affects wildlife in a variety of ways, varying between different types of animals. The reaction to noise often varies with sex, age, season, habituation to noise, noise level and frequency spectrum.

For example, it is known that for many types of bats, owls and birds, noise pollution is changing normal ways of life, affecting the found and hunting for prey. Too much noise could put these animals at risk of extinction by making environments unlivable. While some birds are able to adapt to noise by tweeting louder, other birds with lower frequencies are not able to adapt their tunes. This may affect their communication for mating, and even propel them to migrate to less noisy environments. In Goa, more concretely in Mandei WLS, which is affected by mining, there is a critically endangered bat species (*Otomops broughtoni*), which may have a decrease in its population by noise pollution effects.

Increasing noise from nearby traffic also has been shown to slow frogs' abilities to listen for and locate male frogs that are calling for their services during the mating season. This situation may suppose a declining in reproductive taxes, and consequently a decrease of frog's populations (Ecoist, 2012).

The vibrations generated by processes such as blasting, digging and hauling have similarly effects than noise, such as suffering stress. Consequently it can produce physiological and behavioral changes, which may affect the routine of organisms causing decreases in populations.

Thus, populations of animals that live around the mines are more likely to suffer population declines due to disturbances caused by noise and vibration generated by mining. In addition, many animals to avoid noise and vibration inconvenience go away from the nearest forest. Consequently, the forest area near the mine has less abundance of fauna.

3. Air pollution

As it has been explained in Chapter 1, iron ore mining and transportation generates pollution and subsequent dust increase the Suspended Particulate Matter (SPM).

As saw in mine's visits from November 2012 to January 2013, dust is deposited by dry deposition on the leaves of the plants closest to the mine (see annexure 1, Figure 4), leaving the leaves completely brown. This fact brings problems to the plants. One of the problems is related with light absorption. Energy exchange between vegetation and atmosphere involves the absorption and conversion of shortwave radiation and the emission of long-wave radiation. However, if dust is deposited on leaf's surface, its optical properties are altered (Lewis et al, 2012). Consequently, decrease the amount of light available for photosynthesis.

The other problem is given by dust particles that may interfere in diffusion of gases into and out of leaves. Depending on the size of the particles, they can block the opening of stomata (smothering stomata), hindering gas exchange (Kumar, 2012).

The two situations lead problems for a plant to realize an efficient photosynthesis, which is the process that gives life to a plant. When it is not functioning properly, the plant will undoubtedly suffer.

The effects of a nutritional deficiency may not kill a plant, but retards their growth and consequently, it brings reproductive problems.

Another impact produced by dust is the change of surface temperatures of the leaf. If plants are in a threatening situation, all the community that surrounds them will be also affected. So, the consequence is changes in structure and composition of plant community, involving change in grazing patterns of animals. Hence, dust pollution may produce changes in the community, altering the biodiversity of the zone.

It must be realized that during the rainy season this impact disappears, as the monsoon rain washes the leaves.

4. Water pollution

As it is described in chapter 1, mining activity negatively impacts to the rivers, estuaries and marine environment, strongly during the monsoon wash-off. There are described two types of effects in the aquatic environment.

On the one hand, there are found the impacts related to water quality. The change of the composition of the water, either by the incorporation of particles in toxic concentrations could be harmful to aquatic life. Such pollution from acid drainage can severely impair the habitat of fish and other aquatic species and/or may bring changes in the spawning grounds, thereby reducing population levels (Udall, 1990). Even where species survive, toxic materials can lower reproduction and growth rates. It is studied that the soluble iron has affected the quality and the quantity of phytoplankton in the water bodies (Alvares and Saha, 2008). Also, the vegetation in the surrounding areas of the water body can be affected by the toxic concentrations of the acid elements (CPCB, 2007).

Moreover, aside from toxic particles, the runoff contributes to increase the suspended solids in water. This causes the high turbidity and siltation of streams and ponds (see annexure 1, Figure 6). The turbidity reduces light penetration in water. Consequently, energy is released as heat and water gets warmer, decreasing the ability of containing oxygen of water. Another consequence of this fact is the reduction of photosynthetic activity of plants and algae that contributes to lowering amount of dissolved oxygen in the water, also. Thus, change in water temperature and decreased oxygen affects the survival of the aquatic organisms, such as algae, fish, worms, beetles, amphibians, birds and particularly migratory waterfowl. Suspended soils imply a serious problem especially in ponds and lakes, where the water does not flow.
A comparison between clam beds and associated benthic fauna, in the Mandovi estuarine system of Goa revealed that this ecosystem has been severely affected by massive inputs of mining in less than 10 year (National Institute of Oceanography, 1985).

Another impact of turbidity would reduce the ability to find food for aquatic animals that feed visually. Also, the solid particles in water can clog the gills of aquatic animals and smother the pond bottom habitat that some species depend upon, such as fish's eggs and insects' larvae (Udall, 1990). So, the sedimentation of suspended particles in water causes the suffocation of the benthic fauna and flora. This situation is very common in Mandovi and Zuari estuaries, due to about the 90% of the Goa's mineral ore is transported through them (Indian Journal of Marine Sciences, 1999).

On the other hand, to mine is needed to extract large quantity of water. This fact leads to the alteration of water courses and scarcity. The change of the water regime affects the growth of vegetation and agriculture in and around the mines. Plants and animals do not have sufficient quantity of adequate water to subsist.

All these negative effects bring to the endangerment of aquatic species of flora and fauna. If aquatic biodiversity changes the species that depend on them will be affected, too.

5. Linear infrastructures

To develop the mining activity has been necessary to construct linear infrastructure such as roads and railways. Besides the already mentioned impacts caused by noise and dust, linear infrastructure are a possible point of impact, as many animals are injured or die due to accidents. Also, roads and railways fragment the forest, causing the previously described impacts.

In mining activity areas, rock pythons, king cobras, which are rare reptiles, have been found dead (Times of India, 2012).

As a main conclusion, the iron ore mining activity pressures generate negative impacts on the Goan flora and fauna. All the impacts involve the loss of organisms either by migration, direct death, disability in reproduction or by growth problems. If the population is found in an isolated area, the population could reach locally extinction. The local extinction of species, could suppose global extinctions.

Mining policies like Mine Closure Policy 2003 and National Mineral Policy of India 2008 require the mines to be reclaimed and rehabilitated post mining. The National Mineral Policy of India 2008 announces that "any abandoned mine should be made richer that what it was before" through refilling the pits and reforestation (Government of India, 2008). However, the mine owners abandon the mines in a state of decay and toxicity once they are depleted, or plant fast growing trees like *Australian acacia*, which is an invasive plant species, and *Casuarina sp.*, which is a coastal plant. As a result, hectares of Acacia or Casuarina give rise to a monoculture in the middle of dense tropical forest.

Therefore, iron mining contributes to the decline of biodiversity and deterioration of Goan ecosystems, especially the Western Ghats and estuarine systems.

III. Highlights

- Goa is the second smallest state of India but is ecologically very rich, in comparison with others. In its limited area are located four clearly distinct ecoregions (Western Ghats, plateaus, alluvial plains and the coastal system) with its own characteristics that allow the distribution of a large number of species of flora and fauna, most of them endemic.

- In Goa are sheltered Goan endemic species and Western Ghats endemic species. It is a very important ecological area as a corridor between the states of Karnataka and Maharashtra, permitting the freely animal circulation.

- Mining in Goa is located in the central-east zone, occupying most of the area of plateaus and along the five protected areas of the state, which coincide with the Western Ghats.

- There are mining licenses within and close to the limits of protected areas, violating the Indian Wildlife Act, 1972.

- It is necessary to limit a *buffer zone* around protected areas to reduce the border effect and protect the maximum defined area of Wildlife Sanctuaries and National Parks.

- Mining activity generates pressures that cause direct negative impacts on the biotic environment. The result is the reduction and isolation of wildlife populations that may be locally extinct, especially those endemic, rare and/or threatened.

- Mining activity affects both aquatic and terrestrial environment. It is important to note that the aquatic environment, such as rivers and wetlands, have no protection figure unlike the Western Ghats.

- The decline of biodiversity and deterioration of ecosystems means the loss of multiple ecosystem services which they provide, such as all kind of natural products, climate modulation, fertility to soils, cultural heritage and others. Thus, humankind would not take profit of them.

- Mines restoration is a process of legal obligation as Mine Closure Policy 2003 require. However, in Goa none of the mine owners take the responsibility to return the affected area in the original state as much as possible. Simply, mines are abandoned.

CHAPTER III

SOCIAL FEATURES

Author: Mireia Planell i Calle

Talukas, demography, social class, dust pollution, water pollution, respiratory health problems, noise and agriculture.

INTRODUCTION

This chapter aims to analyze and understand how the Goan population and how mining activity has been developed in this society.

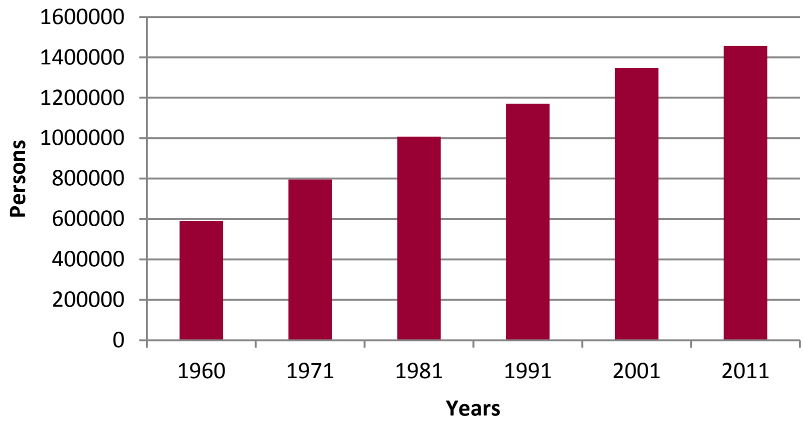
We shall take the following questions into account: How does the demography of Goa compare with other neighboring States of India?, What are the main features of the population of Goa?, What are the profiles of the mine workers?, What effects, both positive and negative, has mining had over population, labor, agriculture, etc.? And finally, try to answer the question of whether mining compensates for all the negative effects that occur.

I. Diagnosis

This section is divided in three subsections. First, it is explained the historical evolution of Goan population since 1961. Second, the current state in Goa with various social and demographic indicators used to compare with their neighboring states, Kerala, Maharashtra and Karnataka, also the density and distribution of jobs for talukas, and finally the religion and migration. And third, a section focusing on society and mining.

1. Population of Goa: the historical evolution

Figure 3.1: Population of Goa (1960-2011)



Source: Census of India 2011

The first data about population of Goa is from 1910. Before the liberation from the Portuguese, Goa had growth rates far below from rest of India. Among 1910 and 1961, the population increased only 22.2%, while in India, for the same years, the increase was 74.2%.

Since the liberation from the Portuguese, in 1961, the population of Goa has increased irregularly. Among 1960 and 1971, the increase was very high (34.77%), while in India was just 24.80%. The following 10 years it fell to 26.74% (same in the rest of the country). Then, until 2001, the growth rate was 15-16%, but the last 10 years, has decreased to 8.17% while the country average is 17.64%. Migration plays a big role in such irregular patterns.

In the early years post-liberation, Goa grew considerably because many people from the neighbor states migrated to Goa to work in the tourism sector and mines. The population has been growing at a slower rate, until today which has a growth rate similar to Europe. This is common to South India. This could indicate that Goa is becoming a modern state.

2. Population of Goa

2.1. Social and demographic indicators

TABLE 3.1: POPULATION CENSUS 2001- 2011

	2001	2011
Area (Sq. Km.)	3,702	3,702
Number of districts	2	2
Number of talukas	11	11
Number of towns ➢ Municipal towns ➢ Census towns	44 ➢ 14 ➢ 30	44 ➢ 14 ➢ 30
Total population ➢ Males ➢ Females ➢ Urban ➢ Rural	1,347,668 ➢ 687,248 ➢ 660,420 ➢ 668,869 ➢ 675,129	1,457,723 ➢ 740,711 ➢ 717,012 ➢ 906,309 ➢ 551,414
Sex-ratio (females per 1,000 males)	961	968
Percentage of urban population	49.63%	62.17%
Density of population per Sq. Km	364	394
Percentage Decadal Growth (2001-2011)	8.17% ➢ Urban: 35.50% ➢ Rural: (-)18.32%	

Sources: Census India 2001 and 2011

To understand the context of Goa is necessary to carry out a comparison with other states. We will compare some demographic and social indicators such as density, mortality, birth and infant mortality rates and literacy.

On one hand, we compared Maharashtra and Karnataka, because these are large states and they are representative of South India. On the other hand, we compared Kerala, because this is a small state and in some ways it is as developed as Goa.

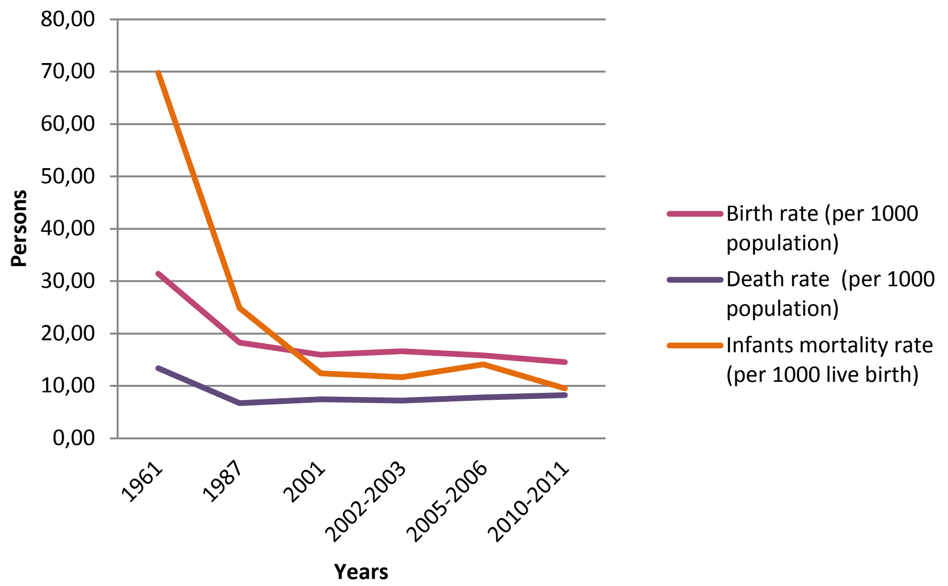
- **Density**

Today, Goa has a density slightly higher than Maharashtra and Karnataka (319 and 365 persons / sq. Kilometers respectively), and the average Indian density (364 persons / sq. km). This is because Goa is a more developed state with a higher standard of living and gathers a variety of activities that attract people from other parts of India to go to work, such as tourism industry.

As for Kerala, it has a very high density of 859persons/Sq.km. Its area is 10 times higher than Goa, and the population is 20 times larger, so its density is higher. Kerala is the most developed state in India, so that it has received much population. To some extent, it benefits from migrant remittances of the Gulf countries.

- **Vital statistics of Goa**

FIGURE 3.2: VITAL STATISTICS OF GOA



Source: Directorate of planning, statistics and evaluation and Own elaboration

In figure 3.2, it is observed that in Goa, since 1961 the infant mortality rate has decreased a lot; it has moved from 69.77‰ (per 1,000 live births) to the current 9.54‰. To understand more about the situation, Goa has nowadays an infant mortality rate similar to that of Catalonia in 1987 (8.71 ‰) (IDESCAT). Compared with other states, Kerala has a similar rate to Goa, although, slightly higher, 12‰. By contrast, Karnataka and Maharashtra have infant mortality rates much higher, 38‰ and 31‰ respectively. However, they are below the infant mortality average in India, which is 50%, and this implies that some states in India have a very high infant mortality rates. Hence, Goa and Kerala have a higher level of development in the field of health care.

The birth rate (per 1,000 population) has decreased since 1961, but remains fairly unchanged from the past ten years. The latest data available is from 2011, where birth rates are very similar in Goa and Kerala (14.52 and 14.16‰ respectively) this suggest that the birth rate tends to decrease, as happens in developed countries, such as Catalonia, in 2011, the birth rate was 10.9 ‰, which has been declining steadily. Regarding Karnataka and Maharashtra, have a birth rate slightly higher, are of 19.2 ‰ and 17.6 ‰ respectively. However, the four states are below the average birth rate in India, which is 22.5 ‰, this could mean that slowly, these states are increasingly getting modern.

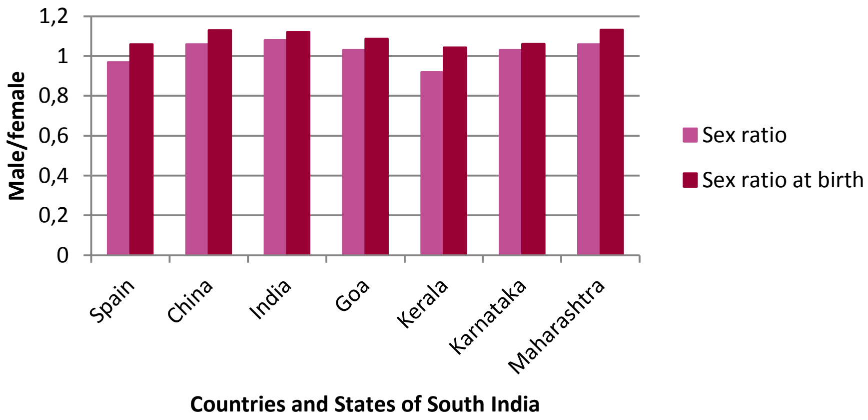
Having a look at the mortality rate (per 1,000 population) in 2011, it was 8.23‰, almost as Catalonia (8 ‰, in 2011), and very similar to that of its neighboring states, Kerala a 6.6 ‰, Karnataka a 7.1 ‰ and Maharashtra with a 6.7 ‰, and also, similar to the average of India, which is a 7.3 ‰.

- **Sex ratio and sex ratio at birth**

Sex ratio at birth has recently emerged as an indicator of certain kinds of sex discrimination in some countries. For instance, high sex ratios at birth in some Asian countries are now attributed to sex-selective abortion and infanticide due to a strong preference for sons. This will affect future marriage patterns and fertility patterns. Eventually, it could cause unrest among young adult males who are unable to find partners.

In Figure 3.3 we compared the two values of sex ratio among India, China (because it is an Asian country with an emerging economy like India) and Spain (to comparing it with a developed European country and familiar to us). We also looked at the differences between the four southern states of India.

FIGURE 3.3: COMPARISON OF SEX RATIO



Source: Data extracted from Indexmundi and Census of India 2011. Own elaboration

The two Asian countries have very similar values; in both the number of men is higher than the number of women. The same applies to the southern states of India that we have studied, except Kerala. Kerala has a value very similar to Spain, where the number of women is higher than men. Among other indicators, this reaffirms that Kerala has a higher level of development than most Indian States.

It is possible that India and China are suffering the consequences of sex selection at birth, as explained above.

Curiously Goa, which has a fairly similar demographic indicators that Kerala, and where the level of per capita income is much higher, nowadays, they are still having a sex ratio at birth that lead to thinking about sex selection, where girls are rejected by their own family.

- **Fertility**[1]

In the last 10 years, fertility has decreased from 1.7 to 1 (i.e., increased from 1 to 1.7 children per woman), while in India the decrease has been from 3.39 to 2.6. Fertility is very low and has a typical value of the developed countries, where it has given more importance to personal growth (formation, education, jobs, etc.) that to family, because children, in more developed societies represent an economic burden and not manpower to work in the field, as formerly.

- **Literacy**

The latest data on literacy rates are from 2011, according to Census of India 2011. Goa, in 2011, had a literacy rate of 87.40% (92.81% male and 81.84% female) in rural areas, the literacy rate was 84.26% (91.71% male and 76.84% female) and slightly higher in urban areas, 89.31% (93.47% male and 84.96% female). It cannot be said that the literacy rate among rural and urban, and men and women are very different.

[1] Fertility is the average number of liveborn children produced by women of childbearing age in a particular society. (Social Science Dictionary)

Considering the evolution of literacy rate, it is observed that the last 20 years (from 1991, where the rate was 75.51%) this has increased nearly 12 points, this is important because it implies an increase in literacy for a larger part of the population.

Compared with other states, there is not much difference. Maharashtra has a literacy rate of 82.91% (89.82% male and 75.48% female), Karnataka is the state with the lowest rate, a 75.60% (82.85% male and 68.13% female), the difference between the sexes is more important. Finally Kerala is the number one in literacy, with 93.91% (96.02% male and 91.98% female). These four states are above the average of India (74.04%), where the difference between men and women is more notorious: 82.14% men and 65.46% women.

Hence, it can be said that Goa and Kerala are leading states in education, and this, is an indicator of how Goa is a state in the important process of developing.

- **Per capita income**

According to recent data, for the period 2011-2012, per capita incomes of the four states were: 133,779 Rs in Goa, 101,314 Rs in Maharashtra, 83,725 Rs in Kerala, and 68,376 Rs in Karnataka.

Goa is the state of India with higher per capita income. This is due to the large exploitation of tourism industry, which attracts tourists from India and from other countries.

The other three states have a per capita income higher than the average of India. Maharashtra has increased much per capita income over the last year.

- **Human Development Index**[2]

India ranks a low 136 among 187 countries in terms of human development index (HDI), which assesses long-term progress in health, education and income indicators.

Comparing the four states, we see that Kerala has the highest HDI. Kerala ranked top with a value of 0.79 (high HDI). Goa ranks fourth with a value of 0.62 (medium HDI), Maharashtra ranked seventh with a value of 0.57 (medium HDI). And finally Karnataka occupies the twelfth place with a value of 0.52 (low HDI). Karnataka has a lower value than the average of India.

In 30 years, India has gone from being among the countries with a low human development index (0.45 to <0.25), to be the medium HDI group. According to *The Times of* India, India's HDI has risen by 1.7% annually since 1980.

Analyzing the various indicators shows that Goa, with respect to population movements (vital statistics) does not follow the general dynamics of India. Although the birth rate and infant mortality are similar among the four states, there is a big difference in the mortality rate, and this reflects a more developed state in health terms and in social welfare policies. It should be mentioned that Kerala and Goa do not differ greatly with these data.

[2] The Human Development Index (HDI) is a composite statistic of life expectancy, education, and income indices used to rank countries into four tiers of human development. It was created by the Pakistani economist Mahbub ul Haq and the Indian economist Amartya Sen in 1990 and was published by the United Nations Development Programme.

Regarding income issues, Goa has a per capita income twice as big as the average of India, and this is reflected in the whole society. In Goa and Kerala there is not so much poverty or homeless people as in Maharashtra and Karnataka, where capita income is above the average India, but, certainly, is poorly distributed.

If we look at the last indicator, the Human Development Index, we see that Goa is still a little far from reaching a high level of HDI. This indicates that despite being a rich state, it is not invested all that it should be in education and social welfare policies.

2.2. Migration flux

The information presented, is extracted from the latest study on migration, Goa Migration Study, 2008, conducted by Frederick Noronha. It was made by surveying households.

Among the two districts of Goa, South Goa district accounts for 60% of emigrant households [3]whereas North Goa district represent just 34%. The emigration rate is estimated as 22.8 persons per 100households in the South Goa but only 10.7 persons in the North.

Among the 11 talukas in Goa, Salcete taluka in South Goa accounted for 51% of emigrant households. After Salcete, the highest proportion of emigrant households was reported in Berdez and Tiswadi (North Goa) with 15% each. These three talukas account for 81% of emigrant households. But these three talukas, account for 89% of return emigrants households[4]. The study results regarding the destinations of Goa's return emigrants. The largest proportion (19%) returned from Kuwait, followed by 16% from United Arab Emirates, 11% from Bahrain and 8% from Oman (the Gulf countries account for 68%). Outside the Gulf region, about 4% return from Australia, 3% each from Canada, the United Kingdom and South Africa.

The religious affiliation of household reveals significant variations. Only 2% of Hindu households reported return emigrants, while 10% of the Christian families in Goa had return emigrants. The Muslim households on an average had 6% of return emigrants.

As for out-migrants[5], of 6000 households surveyed, only 211 households had out-migrants (4%), and of these, only 70% had one member out of the country.

In Goa, out migrants, like their counterparts (emigrants), are better educated than the general population. The 67% of the migrants have at least a secondary level educational qualification, while the corresponding percentage is just 28% among the general population.

In 2008, the largest proportion (57%) of Goan out migrants lived in Maharashtra, followed by 18% in Karnataka and 4% in Delhi.

As immigrants from other states, according to the 2001 census, the numbers were 120,824 (10.3%).

[3] Emigrants are defined as members of the household who had moved out of Goa and were living outside India.

[4] Return emigrants are members of household who, in the past, has emigrated out of India but had return to Goa and were members of the household at the time of Goa Migration Study 2008.

[5] 2008 Out-migrant are defined as members of the household who moved out of goa and were living outside Goa but within India at the time of Goa Migration Study 2008.

Regarding internal migration flow, interestingly, among the urban to rural category Goa ranked top with 26.7% (48,288 persons) of the intra-state migrants, this could be due to various reasons as retirement, illness or returning to the parental home. The other factor could be better communication to commuters from adjacent areas to urban centers for work.

2.3. Talukawise density

TABLE 3.1: TALUKAWISE DISTRIBUTION PER AREA AND POPULATION, 2001

District/Taluka	Area in Sq. km.	Population	Density per Sq. km.
North-Goa	**1736.00**	**758,573**	**437**
Tiswadi	213.57	160,091	750
Bardez	263.97	227,695	863
Pernem	251.69	71,999	286
Bicholim	238.80	90,734	380
Sattari	489.46	58,613	120
Ponda	292.78	149,441	510
South-Goa	**1966.00**	**589,095**	**300**
Sanguem	836.82	64,080	77
Canacona	352.04	43,997	125
Quepem	318.25	74,034	233
Salcete	292.94	262,035	895
Mormugao	109.13	144,949	1328

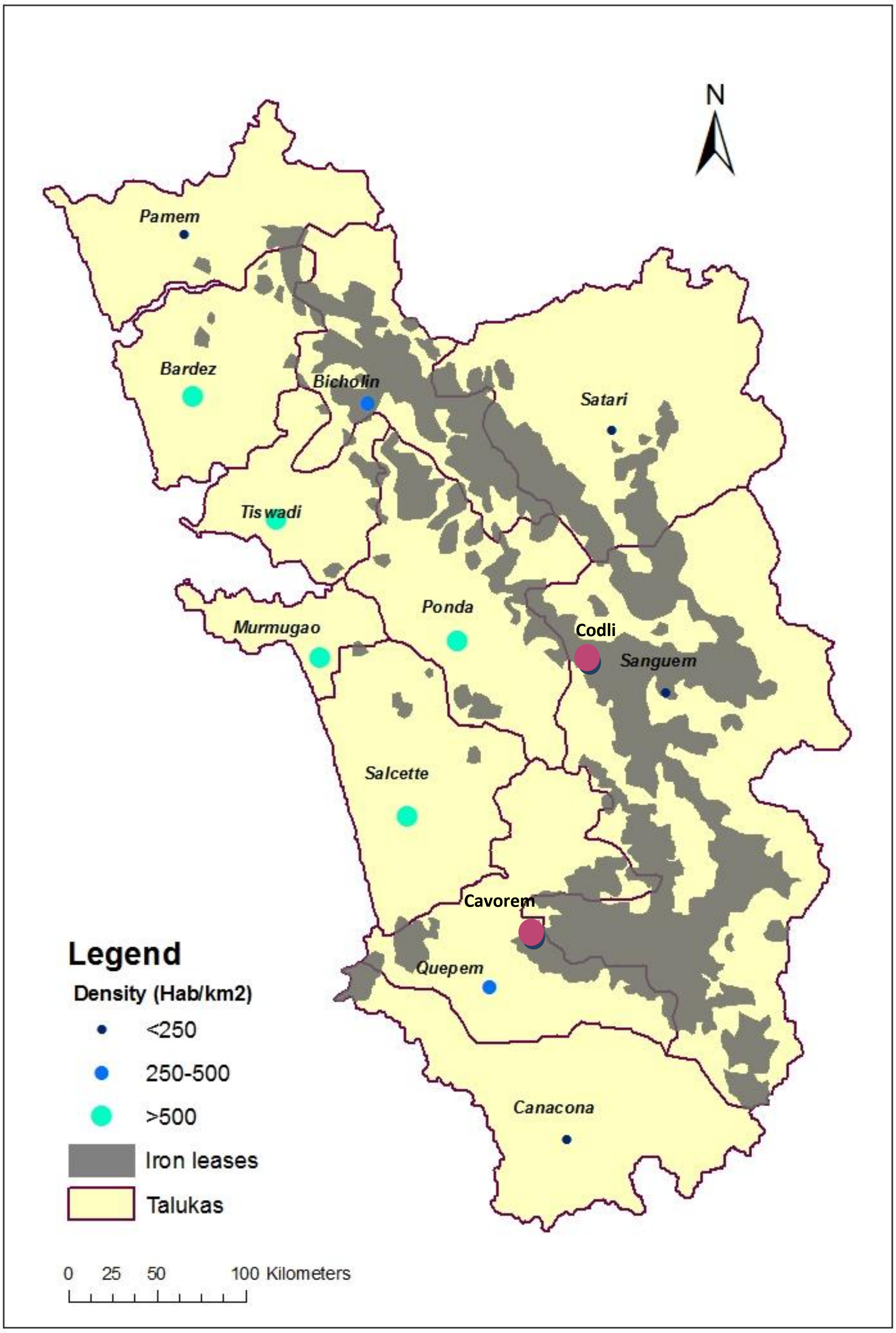
Source: Statistical Hand Book of Goa 2009-10

Sanguem and Quepem are the two talukas where the mines studied are found, particularly in the outskirts of Codli (Sanvordem) and Cavorem (Quepem). In the table above, it can be seen how Sanguem has the lowest population density; it is the largest region of Goa and few people live there compared to other states.

Sanguem is an interior region and therefore is a very rural area, where there are no large cities and few small towns like Codli, which possesses the largest mining exploitation of Goa called *Codli mine*. This mine is operated for many companies, including Sesa Goa Ltd., which it has been object of study in this project.

Quepem extends from west to east of the state, therefore, has urban areas on the coast and rural areas in the interior. Cavorem and Rivona are two Quepem villages with a lot of concentrated mining and consequently, the environment is strongly affected.

MAP 3.1: DENSITY OF POPULATION IN GOA AND IRON LEASES



Source: Llavina Pascual, Xavier

2.4. Distribution of jobs

TABLE 3.3: TALUKAWISE DISTRIBUTION OF WORKING POPULATION BY INDUSTRIAL CATEGORY, 2001

District/Taluka	Total Workers (Main workers and Marginal workers[6])	Cultivators	Agri. Labourers	Household Industry	Other Workers
Goa	**522,855**	**50,395**	**35,806**	**14,746**	**421,908**
North-Goa	**242,190**	**31,501**	**22,216**	**9,221**	**244,690**
Tiswadi	53,212	1,916	1,826	1,306	55,201
Bardez	72,661	3,470	2,711	2,248	78,738
Pernem	20,869	11,709	3,574	1,840	19,155
Bicholim	28,907	4,815	3,494	1,230	25,872
Sattari	28,907	5,297	5,276	1,032	15,475
Ponda	49,965	4,294	5,335	1,565	50,249
South-Goa	**183,115**	**18,894**	**13,590**	**5,525**	**177,218**
Sanguem	20,698	3,842	4,402	764	17,650
Canacona	13,831	6,284	1,212	491	9,670
Quepem	24,297	6,213	3,450	905	19,774
Salcete	79,219	2,169	3,475	2,814	80,673
Mormugao	45,140	386	1,051	551	49,451

Source: Statistical Handbook of Goa 2009-10

In table3.3, we contemplate the primary sector employment, particularly of agriculture (dominant part of the primary sector) with 19.3% of the working population. The second main industry in primary sector is mining and quarrying. Particularly mining, in which the number of workers is uncertain. Depending on who does the study, the variations are enormous. The NCAER 2004-05 states that the mining use, directly or indirectly, about 75,000 workers in the labor force status of 582,274. This is close to the estimated 84,150 tourism jobs. However, economist Rahul Basu estimated the number of mining jobs at only 21,873. He also says that the mining stopped during the monsoon, so the actual core of Goan employment is unlikely to exceed 5,500.

Tertiary sector, dominated by the tourism, is the industry with the largest number of employees (84,150 businesses), as well as providing the greatest amount of income to the state.

[6] **Main workers** were those who had worked for the major part of the year preceding the date of enumeration i.e., those who were engaged in any economically productive activity for 183 days (or six months) or more during the year.
Marginal workers were those who worked any time at all in the year preceding the enumeration but did not work for a major part of the year, i.e., those who worked for less than 183 days (or six months).
Non-workers were those who had not worked any time at all in the year preceding the date of enumeration. (*Indian District Database*)

2.3. Religion

Due to the large Portuguese influence, Goa, has maintained a high percentage of Christians. However, Hinduism is the religion most practiced in Goa. In addition, there are less Muslims than in India on average.

Between Hindus and Christians add up the 92.46% of the population, leaving a low representation of other religions. Contrary to the rest of India, Hinduism is also dominant, but the second most practiced religion is the Islam.

In Table 3.4, it can be seen the percentage distribution of people according to their religion, in Goa and India.

TABLE 3.4: RELIGIOUS COMMUNITIES IN GOA. 2001

All Religious Communities	Goa	India
Hindu	886,551 (65.78%)	80.46%
Christian	359,568 (26.68%)	2.34%
Muslim	92,210 (6.84%)	13.43%
Sikh	970 (0.07%)	1.87%
Jain	820 (0.06%)	0.41%
Buddhist	649 (0.05)	0.77%
Other Religious Communities	353 (0.03%)	0.72%
Religion not stated	6,547 (0.49%)	-
Total	1,347,668 (100%)	100%

Source: Census of India 2001

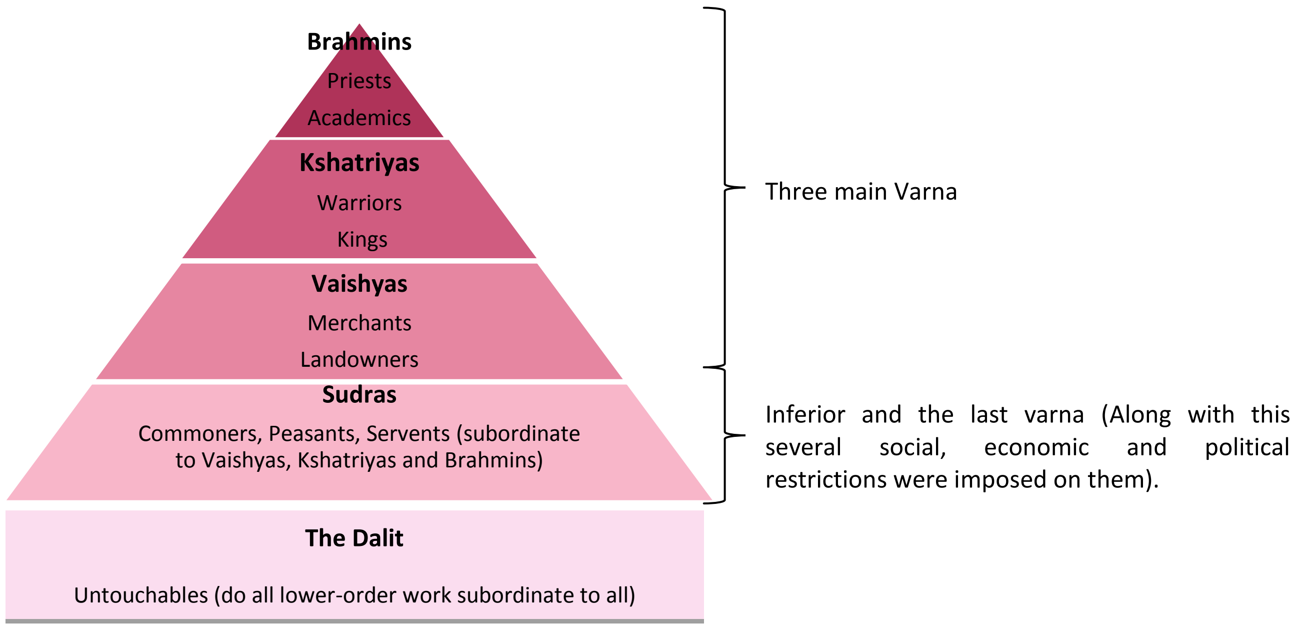
3. Caste system

In the ancient period of India, the backward castes had been denied all kinds of social and economic endowments. Hence, they had been lagging behind in the process of development. The social and economic deprivation among Scheduled Castes had been most common during pre and post-independence. Therefore, there was a need of number of special safeguard policies. One of that is, 'Reservation Policy' in the Government Recruitment. The objective of the reservation policy is to eradicate the social and economic disparities which existed in the society.

The Indian Constitution of 1948 made provision of reservation for "backward" castes in educational institutions and public employment. The reservation policy has to be followed by both, Central and State government. When the first Backward Classes Commission was constituted on 29th January 1953 under the chairmanship of Kakasaheb Kalelkar, he wanted economic backwardness to be the criterion and not caste in deciding backwardness. But the majority of the members wanted caste to be the criterion, to decide the backwardness.

Finally, the government accepted the reservation policy. The social and economic lifting of Scheduled Castes and Scheduled Tribes could be made through the reservation policy. Social inequality is a product of Hindu-Caste System. Hence, protective discrimination policy like 'reservation policy' must be adopted. The Government of India has been following this policy in the recruitment. The reservation policy is being followed in recruitment and also in education. Tribals are included in reservation polices, but not Muslims or other minority religions.

FIGURE 3.1: ANCIENT HINDU-CASTE SYSTEM



Source: Own elaboration

These classified "Dalits" include various groups, which have suffered social and economic inequity for ages. They had to stay outside the village. The concept of pollution was attached to them and they were treated as untouchable castes.

The Untouchables occupy a place that is not clearly defined by boundaries and is outside of the varna scheme. Their jobs (such as toilet cleaning and garbage removal) cause them to be considered impure and thus "untouchable."

Untouchables were officially defined as depressed castes in 1932 and they were systematically listed in the 1931 Census of India. Gandhi named the untouchables as "Harijans". "Hari" means "God" and "Jan" mean "People", that is "People of God". The meaning of this word in Hindi, Marathi and other languages is, "a child, whose father's identity is unknown". Therefore the name "Harijan" was opposed and is hated by the untouchables, who preferred "Dalits". Historically the untouchables were not allowed in temples and many other public places.

In 1935, the Simon Commission first coined the term ‘Scheduled Castes’. All the untouchable castes, which were listed in 1931 in Census of India, came to be known as the ‘Scheduled Castes’ (SC's) through the Government of India Act of 1935. In the mean time, the Government published a list of Scheduled Castes under the Government of India (Scheduled Castes) Order, 1936. The Government of India in post-independence period carried the same idea. According to the Constitution of India, under article 341, the President of India, specifies that, “the castes, races, tribes or parts of groups within castes or races, which shall be deemed to be Scheduled Castes”. Accordingly the President has notified the Scheduled Castes in the order called Constitution (Scheduled Castes) Order-1950 and the Scheduled Castes and Scheduled Tribes List (Modification) Order-1956.

In a way, social justice has been denied by the SC even in the contemporary era. In spite of a constitutional provision, the quota policy has been neglected. This should be taken as a violation of the Constitution. There must be a representation of castes in places of decision making, which could further help for the development of the SC as a whole. The same type of trend could be found among the tribes (STS).

The first category, called SC, includes low castes and "untouchables". The untouchables call themselves "Dalit", meaning depressed. Backward Classes is a category where includes who belong to Sudra varna, and also former untouchables who converted from Hinduism to other religions. This category also includes the nomads and tribes who made a living from criminal acts.

The third category is Scheduled Tribes. This category includes in it those communities who did not accept the caste system and preferred to reside deep in the jungles, forests and mountains of India, away from the main population. The Scheduled Tribes are also called Adivasi, meaning aboriginals.

The Table 3.5 shows the population of Goa, included in the S.C. category and S.T.

TABLE 3.5: TALUKAWISE DISTRIBUTION OF POPULATION OF SCHEDULED CASTES AND SCHEDULED TRIBES, 2001

India/ State/District/Taluka	% of S.C. to total population	% of S.T. to total population
India	**16.20**	**8.20**
Goa	**1.77**	**0.04**
North - Goa	**2.25**	**0.04**
Tiswadi	1.85	0.03
Bardez	2.62	0.05
Pernem	4.17	0.09
Bicholim	2.43	0.04
Sattari	2.02	0.01
Ponda	1.18	0.01
South - Goa	**1.14**	**0.05**
Sanguem	1.35	0.02
Canacona	0.53	0.06
Quepem	0.84	0.01
Salcete	1.19	0.05
Mormugao	1.29	0.06

Source: Statistical hand book of Goa 2009-10

Compared to the average of India, in Goa there are very few people belonging to SC and much less to S.T. Nevertheless, in our work, in the mining territory we found frequent reference of tribal groups leaving in the Western Ghats area.

4. Mining and society

Currently the mines are closed due to the investigations to assess whether it complies with the law or not. Therefore, nowadays, the mine workers carrying machinery, trucks and autonomous trucks drivers, are unemployed. Likewise, the government has required companies to pay workers otherwise the licenses will be removed, but this does not cover the autonomous trucks drivers that are now without work and without salary.

To explain the following sections, the study focuses on the company Sesa Goa, as it is the only company that could be accessed and provided information.

4.1. The workers

There are different profiles of workers. The high positions mainly are occupied by men and some women, both with college degrees. The laboratory technician's jobs are mainly done by women with college degrees, graduates mainly in chemistry. The heavy machinery operators who work directly in the mine, are men. Finally, truck drivers, mostly autonomous workers are also men.

In Goa there has been immigration from neighboring states, people who have come to work in the mine. Much of workers (machine operators) are native to Karnataka, whereas truck drivers are from Biher.

In 2009-10, Sesa Goa had 2,691 employees based in Goa. We add another 1,200 employees of V S Dempo, which was acquired by Sesa Goa during the year totaling 3,891 employees. This includes employees in a variety of non-mining activities such as pig iron, metallurgical coke and ship-building/ship yards, as well as employees for operating vehicles, river fleet, aircraft and ships. Sesa's iron ore segment's operational expense was 80.5% of the total operational expenses and 72.7% of the total iron ore was in Goa. If we were to proportionately estimate employment to only Goan iron ore (73%), we get a figure of 2,277 (=3,891*.805*733). (Rahul Basu. Mining in Goa: Beyond Forest Issues)

4.1.1. The women role inside the mine

Women do not make hard works in the mine, such as machine operators, but have department head positions, engineering, laboratory technician and administrative.

The profile of women is primarily young women (25-30) with university degrees. This means that relatively recently, women have joined the labor market of the mine. Generally women in Goa (and India) have taken care of the family and the house.

4.1.2. Work hours and salary

The mine is in operation 24 hours a day, 365 days a year. There are always people working. Women cannot work after 19:00 pm, so cannot do night shifts

Regarding salaries, according to information provided by Joseph Cuelho (Business manager of all South Goa), machine operators earn 5.000Rs/month, an engineer 100.000Rs/month and a truck driver 25.000Rs/month.

4.1.3. The castes in the world of mining.

The issue of caste is very uncertain. All people interviewed during our stay in Goa, gave no importance to caste. They explained that the caste system in Goa has lost weight. Today is an important classification system, but the old "rules" are no longer fulfilled. Castes were not linked to income level, so a person belonging to the lowest caste, if they have the opportunity, they could get as far as another person from a higher caste.

Apparently in Goa, castes are not a barrier to accessing a job. However, belonging to high castes, the Brahmins and Kshatriyas, as they always been at the top of society, are in a privileged position. In contrast, the low-caste, have to fight harder to gain access to jobs, that for birth, are not corresponded.

4.1.4. Environmental awareness of employees

The mineworkers did not express their opinion on the environment and the damage that the mine produced, because, they get a living from the mine, and therefore, they did not want to talk about it.

In contrast, people living near the mine, which is 20% of the population of Goa, who suffer the mine effects, are aware of the direct damage to the environment, as they see how the agricultural fields have fallen due to increased size of the mines, as wells as the water they get for drinking, cooking, etc. There is increasingly less water and more dust produced by the mine, which effects on people’s health.

II. MINING EFFECTS ON SOCIETY

This section focuses on the mining-society links. First, see how mining activity affects the people health (i.e., what are the main diseases and those who suffer from them). Second, analyze the opportunities or weaknesses that mining generates. Third, explained the conflicts with the tribes.

1. Health problems caused by mining activities

Mining and associated activities contribute to environmental degradation that leads to adverse health 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, we can find trucks circulating through residential areas. The trucks owners have 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 contribute to pollution levels. Further, 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 and particulate air pollution. (Rama Belap, 2012)

Among all the emitted particles, the most dangerous are fine dust particles less than 10 microns in aerodynamic diameter (PM_{10}), because they are in the breathable range and are responsible for health effects. These soluble air particles pass into the blood stream after inhalation and deposit in the respiratory system. The site of deposition of the inhaled air particles determines the clinical response.

Long term exposure to ambient air pollution can cause acute and chronic respiratory diseases such as pneumoconiosis, bronchitis, bronchial asthma, emphysema (lower respiratory disease), and upper respiratory disease.

Further the exposure to fine dust can cause *cor pulmonale (pulmonary cardiac disease)*, *viral infections like pneumonia*, *pulmonary irritation and heart problems*. Additionally, the exposure to high levels of particulate air pollution can cause *impaired foetal* and *problems of infant growth and development*.

It is also important to remark the adverse impacts of inhalation of iron ore or oxides of iron. The PM_{10} and $PM_{2.5}$ particles form oxides of iron (ferrite, ferrous) cause dysfunction of respiratory and immune system. Furthermore, inhalation of soluble iron ore particles causes cardiopulmonary toxicity. Inhalation of iron ore dust can also lead to pulmonary siderosis (Gurzau et. al., 2003). Also, inhalation of iron ore (radon daughter) and taconite fibers (type of iron ore) can be a cause of lung cancer, bronchus and trachea. (TERI, 2006)

However, iron ore particles are not unique cause to respiratory illness. Families with poor economic status use unprocessed solid biomass fuels for cooking and are consequently to high indoor levels of particles, carbon monoxide and other pollutants. This can also cause further respiratory health problems.

Exposure to air pollution depends on the location of the house relative to the road, as well as, occupation, cooking fuel being used and the duration of time spent in polluted area. Further respiratory health problems in the mining area depend on exposure levels and a variety of socio-economic factor such education, access to health care, nutritional status, etc.

To explain the environmental - health linkages use information drawn from interviews with various people involved in the issue of mine in Goa and also data from the study by TERI.

In an interview with Dr. Awdhuta Prabhudessai, a specialist in occupational medicine of primary health center of Colomb village (Rivonia), and activist against mining, explained that health centers do not perform exhaustive records of patients or diseases diagnosed.

He believes that it is difficult to perform studies about how mining affects the health of people, mainly because of two problems: on one hand, people rarely go to the doctor, either by distance or they do not know the symptoms of a disease. And on the other hand, this study is costly, both in monetary terms and time, the government does not give grants.

In his experience, the main diseases and affections produced by mining on people are:

- **Pneumoconiosis:** is an occupational lung disease and a restrictive lung disease caused by the inhalation of dust. Is very common in children and seniors, as the immune system is weaker.
- **Permanent deafness:** in many miners and villagers, due to the road trucks that generate 100 dB.
- **Manganisme:** is a disease that is taken through contamination of water by manganese particles dissolved in water. When removed the soil with water, these particles going to stop to groundwater, and finishing in the water sources where people draw water for drinking and cooking. This disease affects the brain and causes a loss of sanity.
- **Tuberculosis (TB):** TB itself does not depend on mining, but this activity produces a lot of dust and this affects the lungs, these people are more weakened and are more prone to the disease.
- **Allergies and digestive disorders**.
- **Alcoholism**

The most recent study about contamination by dust particles and respiratory diseases associated was made between 2003 and 2006 by The Energy and Resources Institute (TERI). This study, works with 5 Clusters. But, we focus only in three. One Cluster falls into Sanguem taluka (Codli village). Another is 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. And the other Cluster is the Control village (Rivona) in Quepem taluka.

1.1. Health problems by dust pollution

The Tables 3.6. and 3.7. , show the air quality by the PM_{10} in the study areas and work:

TABLE 3.6: AVERAGE PM_{10} CONCENTRATION (µG/M3) IN VARIOUS MICRO ENVIRONMENTS

Mining area	Average PM_{10} concentration (µg/m^3)	
	Ambient (outside the house)	Indoor (living room)
Codli town (mining area)	299	208
Road Corridor (Curchorem town)	436	308
Control (Rivona)	102	114

Source: TERI report no. 2002WR41

TABLE 3.7: AVERAGE $PM1_0$ CONCENTRATION (µG/M3) IN WORK MICRO ENVIRONMENTS

Workplace	Average PM_{10} concentration (µg/m^3)
Outdoor working	467
Inside the mine office	357
Driving	480

Source: TERI report no. 2002WR41

In the mining area and the Road Corridor the air quality is higher than the standard of 150 µg/m^3 for industrial areas. Among those working mining and allied jobs, truck drivers are exposed to the highest respirable suspended particulate matter (RSPM) more than double the 150 µg/m^3.

Another interesting data is that women suffer from a higher exposure than men in Control area. This is because women are more exposed to RSPM from cooking micro-environment which has emerged the highest compared to other micro environments. In contrast, the difference between average male and female 24 hour exposure was marginal in the others Clusters.

1.1.1. Health impact

The main limitation to the study is that in the Clusters area there are only seven healthcare centers. The reporting from these seven centers is poor and incomplete.

The data collected 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 3.8.

TABLE 3.8: CLASSIFICATION OF RESPIRATORY ILLNESSES

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

Source: TERI report no. 2002WR41

- **Resp. non-communicable diseases**

According to data provided by TERI report, in Sanguem, among 2001-03, the LR illnesses have increased, especially between 2002 and 2003 (0.7 to 2.1% of population). In 2002 the UR illnesses were increased and in 2003 were decreased from 3% to 1.9%.

- **Resp. communicable diseases**

In Sanguem have increased UR cases and decrease LR cases. However, the extremely low number of LR cases in 2004 (10 cases) also suggests that the reporting may have been very poor.

If looking at all respiratory communicable diseases together, it can be seen a substantial increase between 2003 and 2004 in percentages for Goa state (6.8% population) and slightly less increase in Sanguem (2% population).

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 it.

1.1.2. Reported health status

According to the study conducted by TERI, the non-respiratory illnesses (sensory illnesses, eye and skin problems and heart ailments) and upper respiratory illness emerged as the most reported illnesses in all groups. In the Road Corridor and Control group in addition to these illnesses, throat and cardiovascular illnesses were highly reported. Lower respiratory illnesses, were least reported in all groups compared to other types of illnesses.

Through a survey, it is studied the influence of different factors to develop respiratory diseases. These illnesses could be related to environmental factors like exposure to high dust and other factors like distance from the road, age groups, education groups, years of staying in the region and smoking. These factors emerged as the significant variables on reporting upper respiratory illness. But the study was primarily concerned with chronic problems that are likely to be related to mining; therefore, more focus was given to analysis of reported lower respiratory problems.

Results of the study conducted by TERI:

- **Age group (<15yrs, 15-29yrs, 30-44yrs, 45-59yrs and <59yrs):** the LR illness is reported more in 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. The LR illness among children is highly reported in the mining areas. In Codli village was reported 36%, followed by the Road Corridor (32.3%). The age group is significant variable in terms of reporting of lower respiratory illnesses.
- **Gender:** the lower respiratory illness develops in 1% and 3% more in men than in women. Therefore, not is significant variation between males and females.
- **Education groups:** the education backgrounds influence in developing illnesses. The number of reporting is highest among the illiterate. Therefore, it can be seen that the higher the educational level the lower reports of disease are presented.
- **Smoking:** in the statistical study, the smoking showed significant results. Therefore, smoking is a factor that increased the lower respiratory illnesses.
- **Distance from the road:** in the statistical study, the distance also showed significant results. Near roads, along which the trucks travel with iron, the presence of dust is higher. This is important because air pollution in the mining areas is primarily caused by heavy vehicular traffic movements.

Thus in the areas of mining, the frequency of developing a lower respiratory illness is greater. In these areas dust pollution is very high, and this can cause various diseases, as it has been stated before.

1.2. Health problems by noise

Mining operations have high levels of noise within the mine, where the noise level of working machinery is between 100-140dB. This is one of the most common occupational hazards and workers should be adequately protected from hazardous noise or distracting noise.

Rama Belap explained that security measures against noise in the mine are scarce, workers do not wear helmets or ear-plugs, as Dr. Prabhudessai has said, "the hearing loss and deafness are common among workers."

Furthermore, the noise should not affect people living in the vicinity of mining, however the continuous passage of trucks during day and night and in the middle of the village, creates a big problem of noise pollution, noise levels in the villages are around 90-100 dB during the passage of heavy vehicles.

Noise affects the welfare of the people, facing prolonged exposure to a noise source, the auditory system suffers, although this one is low level. Noise pollution affects not only the ear but can cause negative effects such as psychological and other physiopathologic effects. Obviously these negative effects depend on personal characteristics; it seems that the stress caused by noise is modulated according to each individual and situation. In Table 3.9 are summarized the harmful effects of excessive noise on the people.

TABLE 3.9: EFFECTS OF EXCESSIVE NOISE

Deterioration of the auditory system	Psychopathological effects	Psychological effects
- The hearing masking: a physiological effect by which reduced the perceptive of a sound due to the simultaneous presence of another sound or noise. - Hearing impairment: transient reduction hearing is recovered after a rest period sound. - The permanent hearing loss: requires exposure to high noise in sound intensity and time, or prolonged fatigue that does not allow recovery. There are organic injuries.	- Dilated pupils and accelerated blinking. - Breathing agitation, accelerated pulse and tachycardia. - Increased blood pressure and headache. - Reduced blood flow and increased muscular activity. The muscles become tense and painful, especially neck and back. - Decreased gastric secretion, gastritis or colitis.	- Insomnia and difficulty sleeping. - Fatigue. - Stress (for the increase in stress-related hormones such as adrenaline). Depression and anxiety. - Irritability and aggressiveness - Hysteria and neurosis. - Social isolation. - Lack of sexual desire or sexual inhibition.

Source: Agència de Protecció de la Salut. Generalitat de Catalunya.

In interviews to people living in villages close to the mines and suffering the pass of trucks during the day, they explained that problems arising from noise are certain.

As explained Mr John Pereira and Mr. Rajendra Kakodkar, two villagers from Sanguem, the most reported effects are deafness, especially in the elderly, because they have been suffering the noise for years, as well as, headaches and difficulty to sleep and rest.

It is possible that they suffer other effects, but they rarely go to the doctor; therefore, it is difficult to know exactly because they are not clinically diagnosed.

1.3. Alcoholism and traffic accidents

Goa is one of the few states where alcoholic drink is allowed.

One of the main problems among immigrants who come to Goa to work in the mines is alcoholism. Mining gives a good salary, and this allows them to buy alcohol. As in their States the alcohol is prohibited, once they arrive in Goa, they do not have measure in the consumption.

According to sources interviewed, alcoholism is widespread especially among truck drivers, which leads directly to the high number of traffic accidents caused by trucks that transported iron ore.

According to data from environmental activist Ramesh Gauna, the average of the traffic accidents caused by mining trucks is the high figure of an accident per week.

2. Impacts of mining on agricultural land and employment

2.1. Employment

The impacts of mining on land have certainly had impacts on livelihoods of agricultural households in the study area. As agriculture has gone into decline with increasing number of landowners that do not use the land for farming or livestock, 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.

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 gender division of labor 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 doing agricultural work. No significant new employment opportunities have emerged for women to fill the vacuum caused by decline in agriculture.

Shri Hanuman Porob activist against mining and president of the NGO Jaishri Gosavarhan Kendra Ram, from village of Valpoi (Sattari taluk), explained during the interview that mining companies had offered jobs to people who had plots of land in exchanging their land. In these areas, companies would place the dumps. This will reduce the land for agriculture.

Rama Belap, one of the founders of Goa Foundation who lives in Rivona (Quepem taluk), explained that companies offered jobs and trucks to the village people. Many people accepted the job and left the field because the salary would be higher. As a result many rice plantations disappeared due to abandoning.

With mechanization, companies covered many jobs (especially laborers), and for 10 years there have not been new recruitments. So they were in a situation where there was no work in the field (because there were very few agricultural lands) or the mining.

This began to make people react because they realized that mining did not give jobs and removed space to agriculture and livestock. As a result of this new situation in the year 2003 there was the first mobilization in South Goa.

2.2. Impacts on agricultural 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 dumps management coupled with the heavy monsoons, leads to the 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 i rural areas where agriculture is a primary source of income, changes on the land have a profound impact on livehoods and human well-being. (TERI, 2006)

Men and women in the study area have reported changes in cropping patterns over the past several years. This includes a shift from crops rotation to growing only rice and the use of chemical fertilizers. Many farmers have stopped growing traditional varieties and have shifted to high yielding hybrids such as Jyoti and Jaya. 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 stilt in water bodies and fields is the central cause of problems in the agricultural system (See in annexure 1, Figure 12). The accumulation of silt over a period of years has several impacts, such as:

- → Lowered soil fertility: The silt accumulated on the land (approximately 80 cm), has little or no organic matter and has low fertility. 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 fertilizers. However, these measures significantly increase the cost of the crops.

- → 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, 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 field waterlogged for long periods of time. As a result, the germinated seeds begin to rot and the crops are destroyed.

- → Lack of water: Due to silting of water bodies, the volume of water flowing through perennial surface 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 was 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 spring have dried up.

While some of these problems can be overcome by increasing inputs (more intensive application of fertilizers, use of pump set, etc.) 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.

3. Impacts of mining on water available

As explained in previous chapters, the mines pumped the ground water, causing the water table fall below the sea level.

The main problem is that this involves the drying of wells and springs (See in annexure 1, Figure 8). The villages near the mines, as Cavorem, Rivona and Codli, have serious water problems, as the springs and wells where they got water for drinking and cooking are dried, or water is dirty and polluted due to mining. There have been detected cases of people suffering diseases related to water pollution, such as digestive disorders and manganisme.

During an interview, the environmental activist Ramesh Gauns, who resides at Pazwada in Bicholim said,

"Agriculture and horticulture was the backbone of my town. Worship of Vaghrodev at Lamgao and Avachitwada tells us that once the tiger was resident of the area. Dhabdhabo, Nagzar all indicate that my land was blessed by water resources. But, today mining activities have forced us to depend totally on Sankhali and Padocem water treatment plants."

4. Opportunities generated by mining

When the large mining exploitations in Goa began, this industry stimulated the economy of rural areas. As explained in the subsection 2.1., the companies offered employment to villagers and provided trucks.

In addition, many people came from other neighbor states of Goa to work in the mines. The immigration waves provided to rural village the opportunity to grow. As a consequence, new restaurants and bars opened in the village. Also many people from rural areas took advantage, and rented their houses to newcomers and moved to the city, where there were job opportunities and they were not isolated as in rural areas.

Now that mining is enclosed, the autonomous workers are leaving, and the small villages close to the mine are getting empty. The businesses that previously had opened taking advantage of the newcomers, are currently closing.

Although the principle, the mining industry seemed a positive thing, with time, it has been seen that mining does not give employment. The impacts of mining, both in health and agriculture, water and environment, need many years to recover. Furthermore, the mining activity is ephemeral and does not compensate for all the damage caused.

5. Compensation of mining companies

Companies have responded to the decline in agriculture by providing compensation to farmers for lost yields. But there is no formal or regularized processes for payment of compensation for reduce yields. The process is ad-hoc and farmer's 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.

However, not every company offset the impacts occurring in the availability of water and health. According to the activist Rama Belap only great companies as Sesa Goa and Fomento, compensate the damage.

Regarding the availability of drinking water in rural areas, these companies provide potable water tanks. To compensate for health problems, companies put doctors at the disposal of workers. According to the activist Rama Belap these doctors hiding health problems and prescribe only what companies enable.

The company Sesa Goa has built schools, provided books and clothes with the intention of silencing people.

But, obviously, all this does not fix the damage. The day that mining will no longer be a profitable business, it will all disappear, leaving this way rural areas more impoverished.

III. Highlights

There are no rigorous studies on the effects of mining in people from Goa, but nevertheless, after studying the situation in Goa and having been there and having seen the impacts of mining to society, it would not be risky to say that mining brings more problems than benefits. In addition, during our stay in Goa, there were many people who shared with us their mining related problems.

It is important to understand that the populations in the mining areas are at risk of developing respiratory illnesses. In addition, 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 were more than double the 150 standard for industrial areas.

According to health status was reported that the eyes, skin and respiratory diseases are the main health problems in all groups.

It has been seen, that age, education and smoking are a statistically significant variable in terms of reporting lower respiratory illnesses. In addition, the distance of the home from the road is also a statistically significant variable. This is important because air pollution in the mining areas is primarily caused by heavy vehicular traffic movement. In the Road corridor, the risk of developing obstructive/restrictive lung function is nine times higher relative to the control group.

As explained above, the noise is also a grave impact on people. Noise affects the welfare of people, facing prolonged exposure to a noise source, the auditory system suffers, although this one in a low level. Noise pollution affects not only the ear but can also cause negative effects psychological and other physiopathologic effects.

Moreover, mining has led to a significant decline in the agricultural sector. On the one hand, many people have left the field to work in the mines, and on the other hand, the accumulation of sediments coming from dumps that flooded the rice fields and water bodies. According to farmers, the accumulation of stilt in water bodies and fields is the root cause of problems in the agricultural system. The accumulation of silt over a period of years has a several impacts, namely: lowered soil fertility, reduced water-holding capacity of water bodies and lack of water. While some of these problems can be overcome by increasing inputs (more intensive application of fertilizers, use of pump set, etc.) 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.

Regarding the availability of water, the villages near the mines have serious water problems, as the springs and wells where they got water for drinking and cooking are dried, or water is dirty and polluted due to mining. There have been detected cases of people suffering diseases related to water pollution, such as digestive disorders and manganisme.

Although at the beginning mining industry seemed a positive thing, with time it has been proved that mining does not give employment, and furthermore, the impacts of mining, both in health, agriculture, water and environment, need many years to recover. Mining activity is ephemeral and does not compensate for all the damage caused.

Chapter IV

MATERIAL FLOW ANALYSIS

Author: Xavier Llavina Pascual

Extraction, Consumption, Iron minig, Energy, Usage, Steel plant.

INTRODUCTION

Goa, one of the smallest States of India, has a particular behaviour concerned to its pattern of extraction. For this reason the researchers are going to analyse the domestic extraction uses for Goa to explain some special uses of materials such as iron ore. Moreover the comparison with Ecuador uses will be provided in the conclusions. Furthermore studying how the iron ore flows through the mining system.

First of all a field work was necessary in order to know which parameters were necessary for the chapter, as well as foreknowledge of the situation. Thanks to in depth interviews with different actors the authors would like to have a general view of how the mine system works.

One of the important assumptions that has been made is that the study of the material flow is focused on one mine: Codli by Sesa Goa. Codli is the company’s main mine and it provides half of the production of Sea Goa´s with 7 million tons per year. Consequently it gives us a representative picture of the reality.

There are different sections that will be analysed in this part. First, the exploration and development will describe the mechanisms to explore the land, critereria to decide if it is profitable or the time that will be necessary as well as the tools needed. With all this information the authors give general mining concepts. Afterwards the main stages of the extraction process will be disclosed. Then the physical processing of iron ore are examined, focusing on the beneficiation plant that is the main way to treat the ore and upgrade it. Moreover the study of dry process that is a paralel stage. The transportation part is also considered although it is not a direct flow from the iron ore treatment so it is important to understand the energy consumption of the mine.

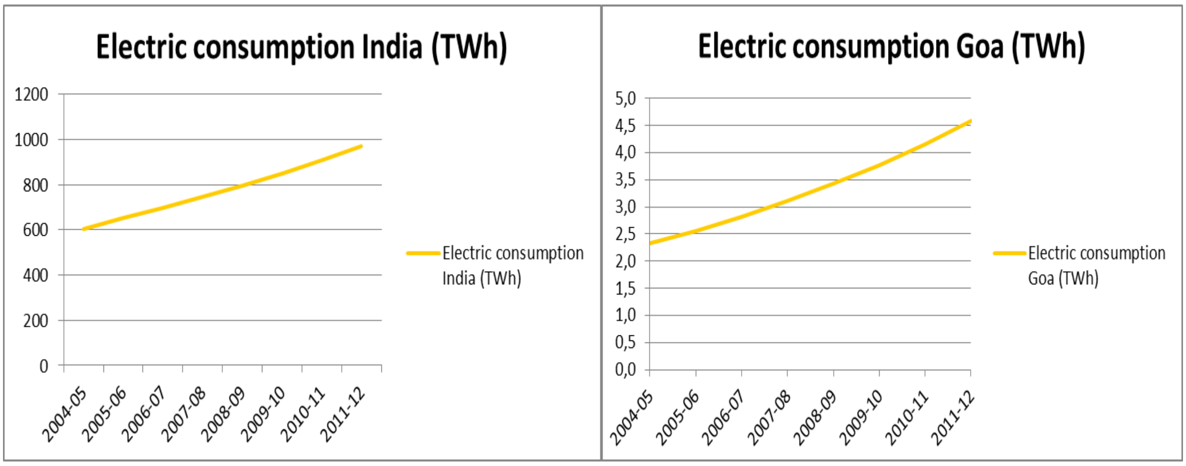
At the end, energy, waste and water uses are described in order to get an holistic view of iron ore flow. The quantity treatment of the data provided during the field work allows us to know the material consumption of the mine activities in Goa.

At the conclusion, the authors will compare the DE of Goa with the DE of Ecuador in order to find some patterns and provide arguments that explain Goa´s behaviour. Furthermore there is a possibility to install a steel plant instead of exporting all pig iron abroad. For this part transportation and power requirements will be taken into account.

1. Material use

India has been named as emerging country (countries that changes their subsistence economy due to being strong industrialized) such as Brazil or China.

FIGURE 4.1: ELECTRIC CONSUMPTION OF INDIA AND GOA.

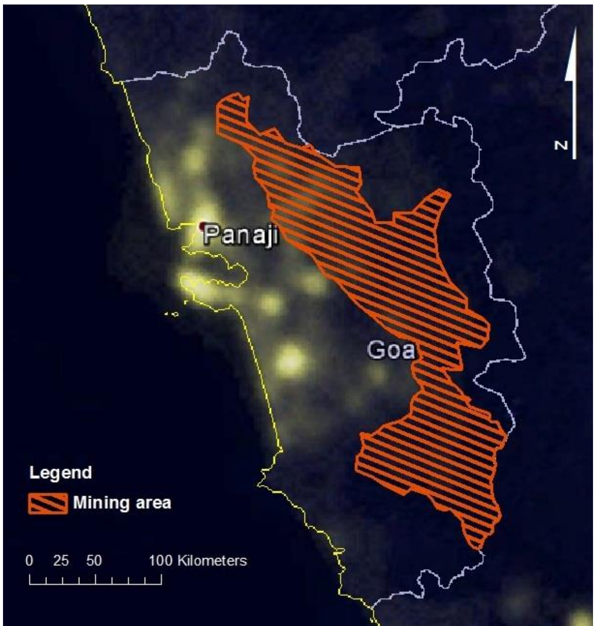


Source: India Electricity Statistics (2009)

The use of energy goes according to the development of the country or State. In this case, the figures show how during the last years the use of electricity has increased because of the development of the country. Therefore, the state of Goa has been following the same way. The electricity demand gives us an idea about the evolution of the material flows in India and Goa.

The electric usage can suggest some patterns of consumption in the country. The figure 4.2 indicates the illumination of Goa at night. It is interesting to study because one can realize that the illumination is stronger near the coast. On the other hand, moving inland the State the illumination decreases due to the presence of the mines which use the electricity for work instead of illuminating the inhabitants of Goa.

FIGURE 4.2: GOA AT NIGHT.



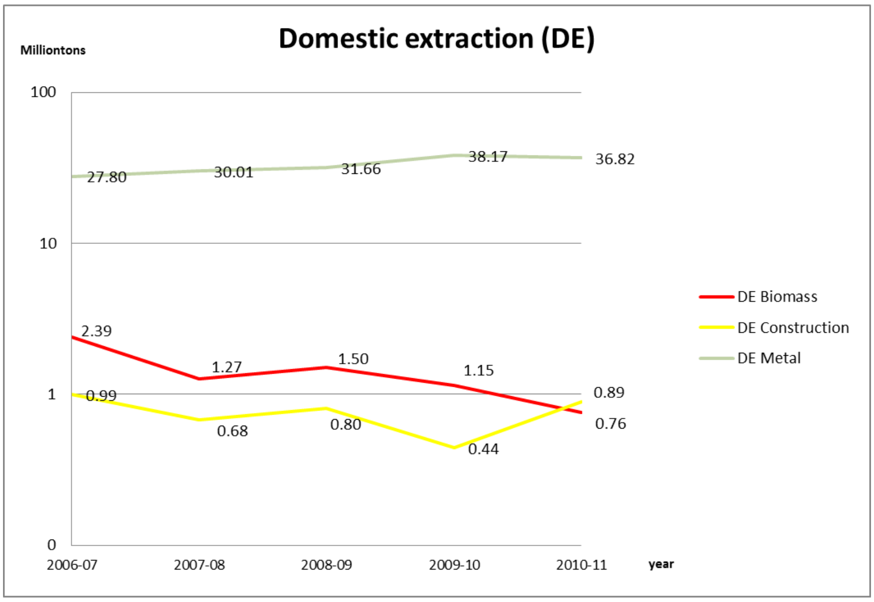
Source: Google Earth and own elaboration.

In the article, *India's biophysical economy, 1961–2008. Sustainability in a national and global context* (Sight et al, 2012) the authors calculated the material flows through the Indian economy using the DMC (Domestic Material Consumption) as an indicator.

The DMC is the result of DE (Domestic Extraction) plus imports minus exports. In order to calculate the DCM, the Domestic Extraction has to be estimated. DE measures the apparent extraction of material for Goa and some parameters are required (Sight et al, 2012):

1. Minerals ores for metals. In Goa the most used minerals are Bauxite, Iron and Manganese ore it could be defined as major minerals.
2. Minerals for building materials. In other words, the materials used for construction as Basalt, Laterite stones, ordinary sand and clay (Minor minerals).
3. Biomass. This part takes into account different parameters. On one hand, it is necessary to calculate the primary crops like harvest crops, fuel wood, timberland, as well fish capture. On the other hand, the researchers have to apply the grazing gap method (Krausman et al, 2007) that is the balance between feed demands minus feed supply. The amount of the primary crops and the grazing biomass is the overall biomass consumed in Goa.
4. Fossils fuels, the consumption has been calculated using the sales of petroleum major products per capita.

FIGURE 4.3: DOMESTIC EXTRACTION.



Source: Own elaboration.

Domestic Extraction indicates that the main extraction is focused on metal mineral ores. This can be explained by the huge extraction of iron ore per year. Total biomass and construction follow a discrete consumption. The results of DE reflect what the bases of the economy in Goa are. The specialization may produce a long term apparition of “Dutch disease”.

The researchers are not able to calculate the DMC due to the problem to calculate the importations of fossil fuels.

2. Exploration and development

Before starting mining activity a study on the pre-feasibility of the process is needed. First of all it is necessary to make a preliminary evaluation of the iron ore deposit which will treat three parts:

- Deposit itself where different parameters are analysed as iron quality, quantity of water, mining deep, slope stability etc.
- Technical aspects include mining, technology options and equipment.
- Economic aspects as mining productions, revenues, investments…

During the deposit exploration the sampling is the most important indicator. The purpose of sampling is to determinate the physical and chemical characteristics of materials related to a potential exploitable ore body. Some of these are done in situ and others are treated in the laboratory. In what concerns iron ore mines the main type of sample is the core drilling. Core drilling consists of rotation perforation with circular drill bit which is cover by diamonds or similar material in order to penetrate into the soil. The result of this process is a cylinder of rock with length about 1.5-2 metres (González de Vallejo, 2002). Thanks to this sample the company may know the rate of iron in soil, the impurities… The amounts of sampling depend on different parameters for each company, basically goes in function of the budget and the foreknowledge of the land (Andrew et al, 2002).

Technical aspects are also important being that dimensions of open pit field, the depth, lateral sides (limitations will depend on the length of the deposits) or rise side boundary has been considered. The boundary must be clearly defined so as to ensure worker safety. After that the construction of the access ramps and haul roads are built in order to prepare the pit design. Pit design will include parameters like geological disturbances, gradient, geological reserves, dumps yards availability, mining system, depth of operation and work practices area.

After defining the pit design and the boundaries the annual production capacity will be fixed based on the following criteria: the available mineable iron reserves, geometry of the deposit, surfaces structures etc. (Satyanarayana, 2012).

The sum of these three parts will result in a conceptual mine plan which will suffer some modifications in order to be optimized. With the pre-feasibility plan the company can decide if the management can start or not. If an agreement is not reached the mine activity may be discarded or the plan will be done again. The process described is applied for an ideal mine.

Sesa Goa, the company which is studied in this chapter, after the pre-feasibility plan has to apply for a prospection license to the local government. Once the prospection license is approved the exploration can start. After the exploration, each company as Sesa Goa, must prepare a 5 year plan which explains the projection production, revenues, number of workers… when the company starts the production, they should make a year plan which is divided into twelve monthly plans where each includes a daily plan. Thereby the government can analyse if the company fulfilled or not with their responsibilities or not once 5 years have passed. With the results Sesa Goa must submit several reports related to the feasibility of the mine. If Goa´s government gives the approval then the mining operations can start.

3. Extraction

When the mine is finally installed the extraction process can start. Again there are a lot of steps until obtaining the iron ore.

There are two forms of breaking rocks: rock penetration and rock fragmentation. The first term mention it is used for all methods with the objective to form a directional hole in the rock which is the principal process to drill a surface rock. There are many types of rock penetration depending on the form of energy: mechanical, thermal, chemical etc. (Route, 2007)

Surface mining as iron ore is the most common kind of drillers. There are the roller bit rotaries and large percussion drills. The main function of the drill is to blast the overburden deposit in order to decrease the power consumption of the excavators as well as the operation cost. Drilling holes is usually made in a zig-zag pattern.

The classification of drilling systems depends on:

1. Principle of working
    - Percussive drilling
    - Rotatory drilling
    - Rotatory-percussive drilling
2. Types of prime mover
    - Used diesel driven drilling machine
    - Electrically driven machine
3. The means of power transmission
    - Pneumatically operated machine
    - Hydraulically operated machine
    - Electrically operated machine in combination with hydraulic and pneumatic system.

After the drilling activity, which it is used to have a better idea about the deposits, the blasting operations can start. The basic objective of blasting is achieving an optimum fragmentation. Blasting in overburden is mainly done either to fragment and break the rock or to displace the rock in the mine area by casting the overburden.

According to explosive rules the explosives are classified in eight types:

1. Class-1: Gunpowder
2. Class-2: Nitrate mixtures
3. Class-3: Nitro compounds
4. Class-4: Chlorate mixtures
5. Class-5: Fluminate
6. Class-6: Ammunition
7. Class-7: Fireworks
8. Class-8: Liquid Oxygen Explosive (LOX)

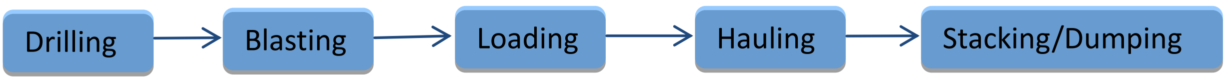
Finally the blast pattern is also important during the extraction process which will define the kind of mining operation. Basically there are two types of blast patterns (Route, 2007):

1. Single row firing pattern, with this type of blasting the fragmentation is low and specific explosive consumption is more than the multi-row blasting pattern so the second one is preferred.
2. Multi-row blasting pattern, can be:
   - Transverse cut pattern
   - Trapezoidal blasting pattern
   - Diagonal blasting pattern

Inappropriate drilling and blasting practices can result in substantial damage to the rock mass within the operating and final pit walls. There is a need to have standardized drilling and blasting patterns that have been determined using well founded and recognized blast design procedures, and that are appropriate to the ground conditions at the mine site (Department of Minerals and Energy Western Australia, 1999). The main goal of blasting is to obtain the mineral ore which it will be loaded, hauled and stacked or dumped according to the quality and the purpose of the company.

The extraction process for Codli mine as it is explained in the field by experts of Sesa Goa Company follows the next stages:

FIGURE 4.4: EXTRACTION PROCESS.



Source: Own elaboration

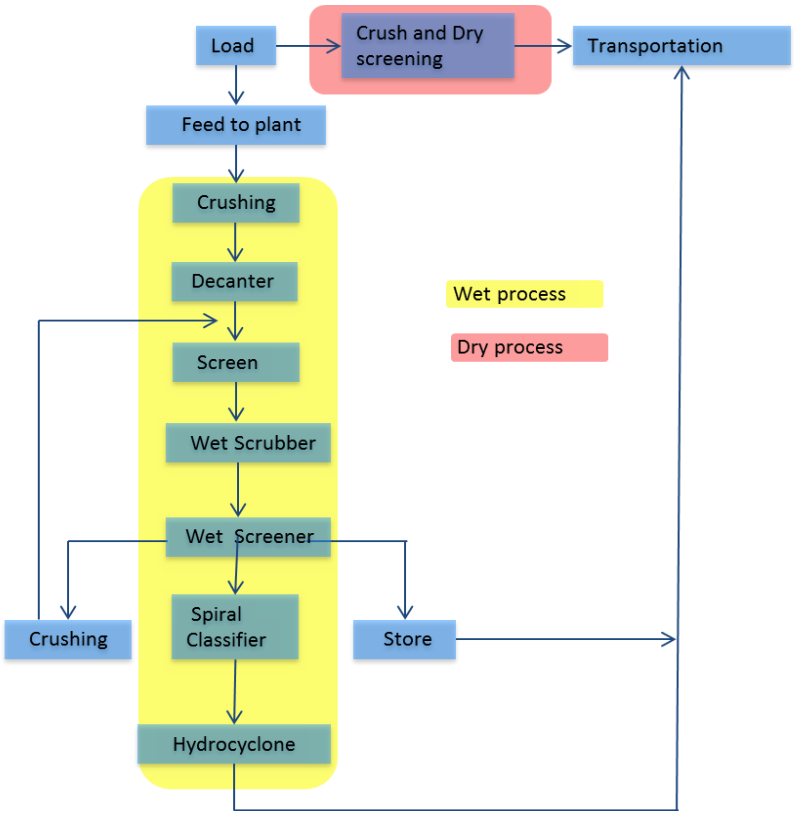
4. Processing

The raw materials are loaded to the Beneficiation plant which is the main plant where the ore is treated. Commonly this raw material is known as ROM (Run of Mine). ROM can be defined according to the size: fines (less 6 mm) or lumps (from 7 to 30 mm) (Global.britanica, 2013). This treatment could be a wet process or dry process which is classified by the iron ore grade. The wet process starts when the stack of iron ore inside the mine is fed into the plant where it will be crushed (Kalavampara and Mascarenhas, 2009). Next it will pass to the decanter. There the flocculants will be added in order to facilitate the primary size separation then the iron ore flows from the decanter to the primary screen where it is separated based on the size. After that the ore goes through wet scrubber to the wet screener which depending on the size will go different ways:

- Particles with more than 30 mm go to a crushing machine and then they are sent out to the screen separator again.
- Between 10 to 30 mm the ore is directly stored.
- Particles less than 10 mm follow the spiral classifier to hydrocyclone that is used to improve the grade of the mineral as well as get the iron ore in forms of lumps.

The dry process is much simpler and it is used for iron ore with enough quality to be sold. It is only passed through one crushing machine and a dry screening machine in order to discard gross material. Thus, at the end, of wet or dry process the mineral treated is transported. The general idea of processing is to achieve the maximum grade possible so the iron can be sold abroad. Typically the rate of grade from iron ore ranges from 57 to 62%. Sesa Goa like all the companies in Goa, exports iron with really low grade and Codli mines are the example of it.

FIGURE 4.5: PROCESSING FLOWCHART.



Source: Own elaboration.

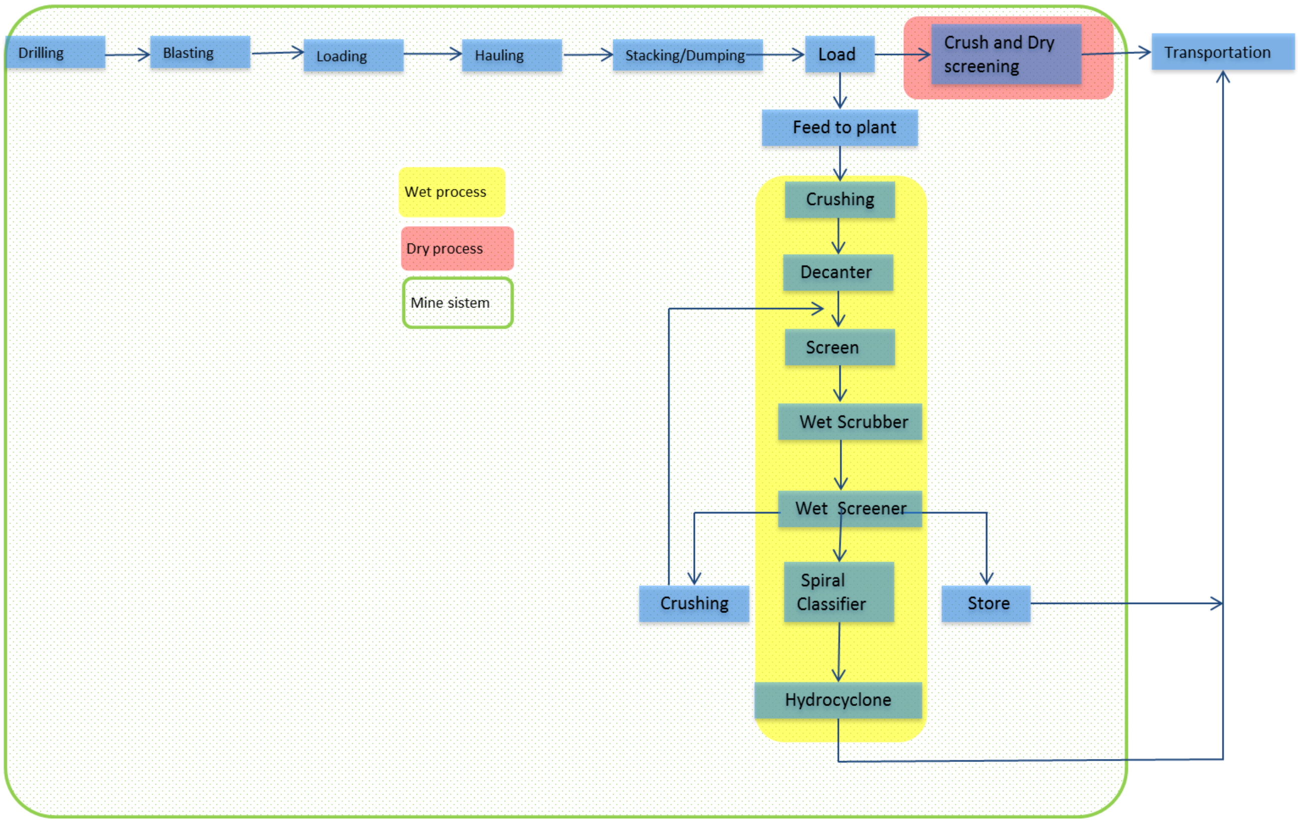
During the wet process a large quantity of water is used. The Beneficiation plant uses a closed water system which allows recovering around the 70% of water. In contrast to 30% of water that is lost after the washing process. Moreover the consumption comes only from the water pits that have fallen during the monsoon. All the waste, mostly mud, generated that cannot be used is sent to the dumps. There the rejected material will be stored in case that someday technology improves and can be used.

5. Transport

There are different kinds of transportation. After blasting the mineral ore Sesa Goa uses big trucks to move the iron from the exploitation area to the plant or storage. Then the company has contracted autonomous staff who carry the iron ore from the mine to the jetties. These drivers travel around 30 Km to the Zuari river where the barges are waiting. From there, the jetties will go to the principal port of Goa which is called Mormugao Port Trust and finally the iron ore will be shipped to others countries like China or Japan. The capacity for each truck is 10 tones.

The transportation causes several impacts because there are too many trucks driving along the national highways, for example Sesa Goa hires one thousand trucks for Codli mines alone.

FIGURE 4.6: IRON ORE PROCESS FLOWCHART.



Source: Own elaboration.

The figure 4.6, includes the complete mining iron ore processing from beginning to end. It does not include the waste generation or the water used, in other words, the material production of the ore from the drill activity to the final transportation to the barges on Mormugao Port.

It is possible to notice that the two main processes: the extraction and processing come together during the final stage where the ore will be exported out of the mine. The flow of the material is a closed flow which has its advantages and disadvantages. For this reason some stages have double the equipment to avoid the collapse of the system in case of failure as well as to speed up the process. Double machinery can be found mostly on the beneficiation plant which is probably the part that suffers problems.

6. Energy Consumption

The amount of energy used is always useful to know because it allows the researchers to calculate others parameters. Moreover, it gives a realistic perspective about how much of resources the activity consumes. Below some calculations are done in order to be conscious of the iron mine requirements.

Chiefly the energy consumption is treated in three parts: exploration, processing and transportation. The exploration process includes drilling, blasting and loading. For processing the authors considered only the beneficiation plant. Transportation includes all the runs done by the trucks inside and outside the mine system. The units are presented in joules which are the main term to represent the energy used. The production activity of Sesa Goa is kept open for the whole year, this means that they work steadily all the year.

Blasting and loading consumptions are well-known due to working in the field while drilling activity must to be estimated by the researchers. The initial units are liter per hour which allows us to calculate the year consumptions.

Part of the transportation is performed in situ and it is done by the trucks of the company which could carry about 150 tons. As well as the autonomous contractors, around one thousand, those take the iron ore from the mine to the harbour. All the calculations for the exploration and transportation are similar from the litre per hour is convert to litre per year then to joules as it is presented on the table 4.1.

TABLE 4.1: TRANSPORT ENERGY CONSUMPTION

Activity	Consumption (ltr/hr)	Daily Consumption (ltr/day)	Year Consumption (ltr/yr)	Consumption (MJ/yr)	Consumption (TJ/yr)
Drilling	-	-	75,000	2,955,000	
Blasting and loading	80	1,920	230,400	9,077,760	
Sum				**12,032,760**	**12.03**
Hauling/Staking	35	840	2,520,000	99,792,000	
Tranport	30	36	13,140,000	517,716,000	
Sum				**617,508,000**	**617.51**

Source: Own elaboration

The total consumption is expressed in Terajoule which equals twelve times one Joule or 1,000,000 Megajoule.

On the other hand the estimates of the processing plant were complicated to calculate because the treatment for iron ore changes according to the production, power requirements etc. The consumption of the beneficiation plant is presented in Kilowatts per year instead of liter per hour due to the electric installation of the plant. The calculations are made base on the required power of the beneficiation plant from Eurobond Industries Pvt. Ltd (EIPL) on the state of Madhya Pradesh (India).

It is possible to estimate the power consumption if the researchers know the total power requirements. The beneficiation plant from Eurobond needs 13 MW. It is only necessary to pass from Mw to Kw then multiply the power by the working hours. In this case they worked during the whole year so it is around 8,760 hours per year. Finally using the equivalence between Kwh and MJ the energy consumption is calculated.

TABLE 4.2: : PROCESS ENERGY CONSUMPTION

Activity	Power requirements (MW)	Year Consumption (Kwh/yr)	Consumption (MJ/yr)	Consumption (TJ/yr)
Beneficiation plant	13	113,880,000	409,968,000	**409.97**

Source: Own elaboration

Total energy required is the total amount of the consumption for transportation, the operations usage and treatment process. It is around 1,042 TJ per year. The authors consider that the consumptions can be higher than the data showed previously because some calculations which have been done were underestimated.

Below using this data the researchers can calculate the CO_2 equivalent emissions. This indicator is used because it shows the potential impacts on global warming for each element compared to carbon dioxide. In this case it will be petroleum. In order to estimate the tons of CO_2e first the Tons of Oil Equivalent (TOE) has been calculated. One TOE equals to 4.18×10^{10} Joules so dividing this factor by the total consumption of the mine system, we found the TOE. Once this is understood, it is only necessary to pass from TOE to CO_2e through the equivalent factor of 3.09.

TABLE 4.3: CODLI MINE EMISSIONS.

Activity	Consumption(TJ/yr)	TOE (tn)	CO2 equivalent(tn)
Drilling, Blasting and Loading	12.03	293.78	907.78
Hauling, Staking and Transport	617.51	14,784.97	45,574.31
Beneficiation plant	409.97	9,791.96	30,257.16
Total	**1,039.51**	**24,834.71**	**76,739.25**

Source: Own elaboration.

Using the statistics from the sustainability report as well as the website of Sesa Goa the researchers can estimate the energy consumption and CO_2 emissions rates of Codli mine, the biggest mine of the company.

In terms of energy consumption, Sesa Goa usage during 2011-2012 is about 2,070,245 GJ which involves direct and indirect consumptions. In the case of Codli mine, the annual use of energy is 1,039,510 GJ then the percentage is around 50.3% of the total consumption of the company. If the researchers focus on the CO_2 emissions, the average for one financial year is 77,060 equivalent tons of carbon dioxide from Sesa Goa Company. In this part, the emissions of Codli mine that have been taken into account includes the direct and indirect flows which are 76739.25 tons.

However the authors have to disaggregate the transportation which mostly counts indirect output. Discarding 84% of the transportation that is the way from the mine system to the jetties the total emissions are 38456. 83 tones and implies 50% of the total CO_2e. Both cases only consider the mine activity and no other processes such as pig iron plant or met coke plant.

7. Waste generation

As we mentioned before the company works all year in order to increase their marginal profits. The problem comes when monsoon period arrives and the production process becomes more difficult. According to Joseph Cohelo, responsible for the South production in Sesa Goa Company, the extraction of material is around one lack tons/day excluding the monsoon period which comes down to 4000 tons/day. Due to security measures, the activity is concentrated at top of the open pit mine.

To compute the waste generation, it is necessary to know how much residue is produced during the extraction as well as how much comes from the beneficiation plant. First of all, the researchers are going to multiply one lack of tons by 8 months that is the dry season in India, this is 24,000,000 tons/year. Adding the extraction produced during the rest of the year which is 480,000 tons per year that corresponds to monsoon time. The total of material extracted is 24,480,000 tons/year (dry season plus monsoon period). This result shows the quantity of material extracted for one year which includes waste and iron ore. According to “NCAER on Mining in Goa: Inconvenient truths” from Basu R. the amount of waste that comes from mining during 2006-2007 from all the companies was about 76,899,187 tons. If the researchers know the production of minerals for this year then it is possible to extrapolate the waste material for 7,000,000 tons of iron ore (Codli mine). In this case it is approximately 18,000,000 tons. It can be said that the waste calculated from the authors is higher because it has been taken into account more parameters for Codli: monsoon period, working hours etc. than the result provides from the article which is an extrapolation.

The knowledge acquired in India allows the authors to estimate the waste generation thanks to knowing that from 1 ton of iron ore manufactured there are 3 tons of waste generated so if 24,480,000 tons/year is divided by 3 the iron ore production are estimated and it is around 8,160,000 tons/year. The difference between the total material extracted and the iron ore estimated is 16,320,000 tons/year which is the waste generated only during the extraction process.

If we know that the total production of iron ore for one year is 7,000,000 tons for Codli mine, the difference between 8,160,000 and 7,000,000 will be the residues collected from beneficiation plant.

These 1,160,000 tons of waste are mainly the result of washing the iron ore to upgrade the quality of it. Now we are going to analyse each stage in terms of waste generation. As it is commented before, the iron ore enters the beneficiation plant where it flows through the belt to the wet screener. Then the iron ore follows different ways according to its size:

- If the material is directly stored, the waste separated is around 116,000 (10%) and the ore quality will be 61%.
- If the iron ore flows to the classifier, almost half of it (50%) will be considered as waste so it is 580,000 tons and the upgrade achieved is also 61%
- The final stage which is the hydrocyclones, the grade of iron ore will be 62%. This means that another 20% of material will be rejected as waste (232,000 tons).

It is possible to say that the main part of waste generation is produced in the classifier. The remaining 20% of waste is divided between the crusher used in wet process and the dry process. The only problem is that the authors cannot determine the specific rate for each.

The next question is: Where does the waste produced go? To answer this question some things have to be considered. For all stages there are collectors that the main function is to store the solid waste in order to reuse it if it is possible and If not it goes to the landfill.

Once all the solid waste is collected from the exploitation and beneficiation plant, it is sent to the dumps. The dumps are a huge amount of solid material with no immediate use for iron ore industry which remains there until use is found. If the dumps are so large they are either filled or they may suffer a recovering process as it is explained in another chapter. This waste is directly exposed to the biotic and abiotic factors so the dumps must be placed under strict and safety measures to ensure that the harmful emissions will be less as possible.

8. Water consumption

According to Sesa Goa they give special importance to the use and treatment of water related with the operations: before, during and after the process. For this reason the company is able to "save" large amount of water.

Mainly the stages linked with this kind of consumptions can be found at the beneficiation plant where the authors will focus on. The monsoon season plays an important role and because of this the company can collect all the rainfall in artificial pits created to extract the ore. The total capacity for Codli mine is around 10 lakh m^3. As the law states, industries that use water for their treatments cannot extract water below the water level which is *the upper surface of an area filled with groundwater, separating the zone of aeration (the subsurface region of soil and rocks in which the pores are filled with air and usually some water) from the zone of saturation (the subsurface region in which the pores are filled only with water). Water tables rise and fall with seasonal moisture, water absorption by vegetation, and the withdrawal of groundwater from wells, among other factors. The water table is not flat but has peaks and valleys that generally conform to the overlying land surface* (Youdictionaryscience, 2013).

Once the water from rainfall is collected in the pits it will be sent to the beneficiation plant where it will be used to wash the iron ore in order to upgrade it. When the water passes through the plant above 30% of it flows to the tailing ponds. In contrast to the 70% that first will be treated and later can be reused at the beneficiation plant.

As the researchers had already studied the waste generation, if we would like to calculate how much water are used some estimations have to be done. To process one ton of iron ore it is necessary to consume 1, 5 m^3 of water. Then if the production of Codli mine is 7 million of tons the water consumption will be 10,500,000 cubic meters per year. Making simple calculations around 7,350,000 m^3 (70% of the water consumption) will be processed. On the other hand 3,150,000 m^3 will be considered as liquid waste.

In order to know how much water consumes Codli mine the authors are going to compare it with Panaji (capital of Goa) consumption. According to Asian Green City Index the average per person is 278 litres in

Asia, multiplying by 365 days which is one year equals 101,470 litres per capita or 101. 47 m^3/cap. Finally it is only necessary to multiply 101.47 m^3/cap by 650,000 which is the total population of Panaji and the result is 659,555,000 m^3 per year. In one year Codli consumes the same amount of water as a city one and a half the size of Panaji.

The Sustainability Report 2012 from Sesa Goa Company shows that the water consumption for the period 2011-2012 was 18,556,795 m^3. Divided by 2 because half of the production comes from Codli mine where the water use is 9,278,397.2 m^3 which is close to 10,500,000 cubic meters calculated by the authors.

The tailing ponds contain the materials left over from the process so it is possible to find all sort of types of materials mixed in the water. The function of these ponds besides storing residual water is to contribute the treatment of the water. This treatment consists of removing those supernatant from the surface of water while it remains in the ponds. In this way the toxins are denser than the water and because of gravity they go to the bottom of the tailing pond to obtain the purification of the water. These toxins are in a solid form so it can go to the landfilled at the dumps as the rest of solid waste generated. At the same time when the monsoon season arrives, it facilitates the dissolution of the toxins due to the rainfall.

The overall process of water consumption follows the next steps:

- Collecting water from monsoon season
- Using these water for washing process
- Part of it is recycled and the other is sent to the tailing ponds
- Tailing ponds collect the residual waters and are refilled thanks to the monsoon season

Theoretically the whole process is closed, as a result, this means the company does not need to collect freshwater from others sources. Moreover, all the waste generated during the iron ore treatment does not escape from the mine system.

9. Conclusions

9.1. Comparison between Goa and Ecuador

TABLE 4.4: COMPARISON BETWEEN GOA AND ECUADOR. NOTE: GOA´S DATABASE IS FROM 2012 WHILE ECUADOR COMES FROM 2000. GSDP=GROSS STATE DOMESTIC PRODUCT.

Country	Population (1000s)	Population density (inhabitants/km^2)	Area (km^2)	GSDP (US$ 1 million)
Goa	1,457	394	3,702	5,460
Ecuador	12,306	43.4	283,560	15,942

Source: Own elaboration and Vallejo M. 2005.

In order to compare and understand the Domestic Material Extraction between Goa and Ecuador, first it is necessary to give a general overview of the South American country.

Ecuador has a population of around 12,306,000 inhabitants distributed on 283,560 square kilometres. It is located in South America surrounded by Colombia in the North, Peru in the East and Pacific Ocean in the West. This country has three natural geographic zones. The Highs Mountains from Andes include two mountain ranges which are the Oriental and Occidental. The Coastal zone is situated between the Andes and the Pacific Ocean where it is possible to find larges extensions of banana, cacao etc. plantations. The Amazon watershed and rainforest are the third part which occupies 36% of Ecuadorian territory. In this territory there is only 3% of the Ecuadorian population. There is another area outside of the physical territory which also belongs to Ecuador and it is Galapagos Island. (Guiadeviajes, 2013)

The main economic activities of Ecuador are the primary and secondary sector. In economic terms Ecuador is well known due to the extraction of petroleum and the production of their agricultural sector based on the banana exportation among others.

Focusing on petroleum production throughout the financial year 2011 it contributed 50.6% to the GDP so this means that Ecuador has petroleum base economy. Mainly Ecuador exports around 40 to 60% of his petrol to different countries (Miradoreconomico, 2012). China is the primary costumer with more than 80% of Ecuador exportations and the rest is divided between Venezuela and Uruguay (Elcomercio, 2013). Agricultural sector is also important because it produces banana, flowers and cacao which are exported. This represents 16% of the GDP. Ecuador is the biggest banana producer in the world. Fisheries have also a relative importance with 5.5% of the PIB based on shrimps selling. The rest of the GDP is divided among others sectors (Miradoreconomico, 2012).

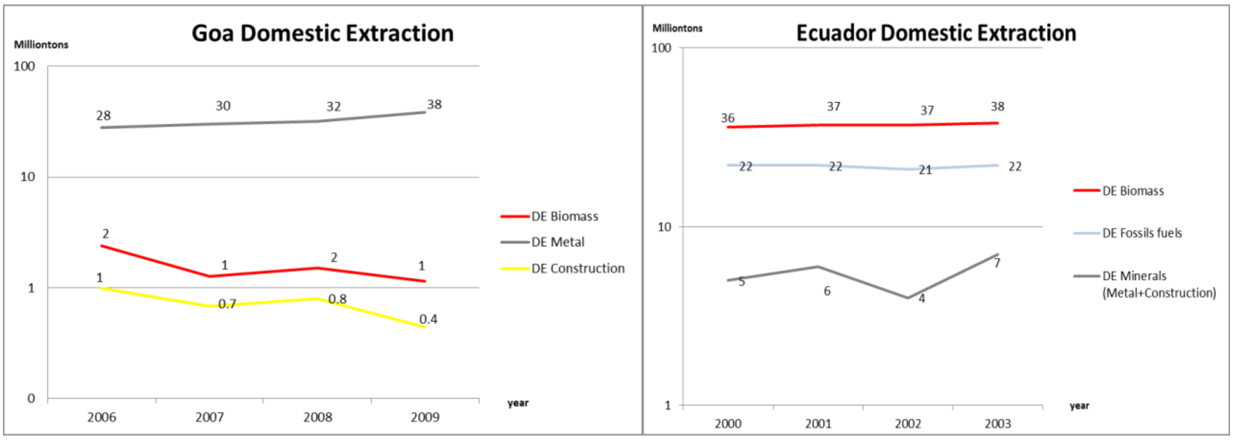
Raw materials that make up 30.6% are the main products imported to Ecuador followed by capitals goods with 26.79%, consumption goods with 22.45% and fuels with 20.22%. The principal countries which provide those materials are United States (26%), China (10%), Colombia (8%) and Brazil (4%) (ProEcuador, 2013). However the imports are distributed around the world. Ecuador also receives products from Europe or Africa.

One important assumption that has been made before is to compare both systems. The periods that have been studied are different. As a rule it is not common to analyse two facts if they do not correspond at the same time. In this case the researchers are looking for similar patterns in order to get a general view of Goa´s behavior. Therefore the results will provide useful information related with to field.

Ecuador has been chosen instead of others countries for different reasons. Goa is a State within India so it is not a country. Consequently it is really difficult for the researchers to find another State, community, area… that belongs to one country in order to compare with Goa. In addition it would be more complicated to find some place if it must have the similar physical size with DMC done in the same period of time. For these reasons, Maria Cristina Vallejo wrote in a report related to the material consumption of Ecuador gives us the guidelines to know how the DMC works. Moreover, it is a challenge to compare two regions with a lot of different parameters.

As it has been mention before Ecuador pertains to South America and it has a bigger area and population than Goa. On the contrary Goa, it is situated in India and this State it is characterized for its high density population. Both economies follow a similar pattern: they depend mostly on one resource and their income highly dependent on it.

FIGURE 4.7: GOA AND ECUADOR DOMESTIC EXTRACTION.



Source: Own elaboration and Vallejo M. (2005)

The patterns of extraction for both systems are similar with a large use of their primary resources. In the case of Goa this extraction is more unbalanced than Ecuador, which produces significant differences between metals and the extraction of biomass and materials for construction. Meanwhile the Ecuador Domestic Extraction is more stable among biomass and fossils fuels. Goa´s behaviour can be explained because its economic development throughout the last years was focused on exploiting their "strengths" such as ore minerals. On the other hand, Ecuador depends on the production of fossils fuels to grow as a country but it has been stabilized as well as the biomass extraction.

A closer examination to Ecuador extraction one can realize that the main intake is the biomass followed by fossils fuels. On the contrary, metals have become the main extraction in Goa. The significant differences between the two countries are that Goa does not have a significant DE of fossils fuels and it is "substituted" for materials of construction. On the contrary, Ecuador produces and consumes this petroleum and derivate products.

Goa´s base is constituted by iron ore production. The industrial sector uses this primary resource to export to other countries which it does not cover the necessities of the population. Probably the high extraction of metals hides the real usage of the material where the biomass will represent a bigger piece as the material for construction or fossils fuels. On the contrary the Ecuadorian case is quiet complex because most part of their primary resources are oriented to export, one example are the luxury items like flowers while the use of fossils fuels are designed to cover the industry needs.

The material consumption in Goa´s pattern for the upcoming years will change. Nowadays the mining activity has been banned due to the lack of environmental clearances. With the real possibility to stop the mining in this area or at list to cut back this production. The researchers believe that Goa´s DE will slow down because of the decrease of the iron production. Maybe it will be substituted by exploitation of others resources like construction materials or it will be considerably reduced due to the reduction of the iron ore extraction.

9.2. Purpose to set up a steel industry in Goa under energy view

Sesa Goa has two kinds of plants in the State: iron ore extraction plant and pig iron production plant. The company sells all their resources abroad mostly to China. In this section we are going to discuss the possibility to install a steel factory in Goa. This discussion will be only in terms of energy. To do this, the researchers are going to make a short description of the pig iron and steel production in order to understand the whole process. Then we are going to compare the use of energy to export the iron ore to China in contrast to set up a steel industry in Goa to produce steel itself. Our hypothesis is that exporting pig iron to China consumes more energy than producing steel in Goa.

- **Pig iron plant in Amona (Goa)**

The Amona´s plant produces around 250-290,000 tons of pig iron per year (Sesa Goa, 2011). In order to clari the researchers would like to describe the process as well as the main aspects of this kind of processing.

FIGURE 4.2: PIG IRON FROM AMONA´S PLANT.

Source: Xavier Llavina

Amona´s plant produces one principal product that is pig iron followed by different sub-products. Pig iron is a product of blast furnace operation where the natural iron ore is reduced to get iron in liquid form. Most of it is formed by iron blended with others constituents such as: Carbon, Silicon, Manganese, Sulphur and Posphours. Then this liquid form is casted into small blocks of 5-7 Kg.

Referring to sub-products there are two common types:

- Slag, resulting from blast furnace process. The major components are Calcium and Silicon which is a perfect raw material for the cement industry. Slag is mixed with water to granulated then is dried to be sold to different industries near Amona.
- Skull is an intermediate product caused during casting and tapping. It is sold according to its size and iron content.

The principal stage in pig iron plant is the blast furnace process. It starts by changing iron ore in form of lump, sinter and coke. The iron ore is moved by underground bins while the coke is transported from the coke plant and stored in the stock house. Both elements are displaced by different belts and dropped alternatively to the furnaces. Once it passes through the furnaces it flows to separate operations. Slag form goes to the slag pool and metal is collected in ladles to be casted into pig iron and stored. (Sesa Goa, 2012)

- **Steel industry**

Before analysing the energy requirements it is necessary to understand how the steel industry works and which can be the best option for Goa.

To produce steel it is necessary to have iron ore, coal and limestone. As we mentioned before thanks to producing pig iron at Amona the raw material are prepared to produce primary steel. The steel can be done by different kind of furnaces (Worrell et al, 1997):

- Open Hearth Furnace (OHF)
- Basic Oxygen Furnace (BOF)
- Electric Arc Furnace (EAF)

The researchers assume that the future industry in Goa will use BOF. However the most common type used in India and development countries is OHF. Nevertheless the BOF process is rapidly replacing OHF because it consumes less energy and capital.

Iron ore goes to the furnaces to be melted and flows to the next step: casting and shaping. Casting could be produced as ingots or a continuous process. The classical way is done by ingots but it was quickly substituted with the continuous casting machines. Then the steel is treated in hot rolling mills where it is a heated and passed through heavy roller section reducing the thickness of the steel. As a result it produces sheets that will be treated by cold rolling. The last step is the end where it will undergo modifications in order to improve the quality of the steel (Worrell E. et al, 1997).

According to Duraiappah A. on "*Computational models in the Economics of Environment and Development*" to produce 1 ton of steel it is necessary 0.95 tons of pig iron. If the average production of Amona´s plant during the last three years was 268,000 tons, the researchers assume that the future steel industry has the capacity to produce around 280,000 tons of steel per year (Visiontek Consultancy services PVT LTD. 2013). The power requirements for one steel plant with this volume of production is around 52 MW as in the case of Bamura plant on Burdwan (West Bengal, India) which it will produces 230,000 tons per year.

Applying the same method as the beneficiation plant it is possible to find the energy consumption. It is only necessary to multiply by hours and convert into energy units. The amount of energy consumption is 1,640 TJ/yr. This calculation does not include the energy wasted during the transportation or the energy required to produce pig iron because it is already covered by the company with or without the steel plan installation. The authors considered that the principal consumption is produced in the BOF.

Taking advantage of this information, the authors would like to estimate if it is possible to produce 1,640 TJ/yr because several sources ensure that Goa does not have the capacity to generate enough energy in order to maintain the steel plant. First of all it is necessary to know the power capacity of Goa which is 418 MW (Cea, 2012) and multiplied by 8,760 hours (for one year) it is estimated the maximum power consumption for Goa which is 3,664,483,200 Kwh. Thanks to Info tech Corporation of Goa Ltd. Goa´s per capita power consumption is 1,160 Kwh. Consequently the real power consumption of Goa is 1,160 multiplied by the total population that is 1,563,294,880 Kwh. By subtracting from 3,664,483,200 still remain 2,101,188,320 Kwh available. The power consumption of the steel plant is 455,520,000 Kwh deducting from 2,101,188,320 Kwh there are 1,645,668,320 Kwh available. In summary it is feasible to install a steel plant in terms of the power available. It is true that this option has not been taking into account by the main stakeholders arguing that Goa cannot maintain it.

Now the researchers are going to analyse the energy consumption to export all the pig iron from Amona to China. Some assumptions have been done in order to make the calculations clear. First of all it is necessary to know which part of China the pig iron is sent to. For this reason the authors choose Xiamen because it is one of the biggest ports of Southeast of China.

The transportation of pig iron goes from Amona to Murmugao port and it is carried by trucks with a capacity of 10 tons over 30-35 km. From there, pig iron will be shipped to Xiamen with bulk carriers. *Bulk carriers were developed in the 1950s to carry large quantities of non-packed commodities such as grains, coal and iron ore* (IMO,2013). These can take between 30,000 to 40000 tons per trip.

TABLE 4.5: TRANSPORTATION ENERGY CONSUMPTION OF PIG IRON FROM GOA TO CHINA

Activity	Consumption (ltr/yr)	Consumption (MJ/yr)	Consumption (TJ/yr)
Bulk carriers	5,082,000	200,230,800	200.23
Trucks	13,140	20,708,640	20.71
Total			**220.94**

Source: Own elaboration

First of all to calculate the consumption of the bulk carries was necessary to know the speed and distance between Amona and Xiamen to calculate how many days a journey takes (11.5 days). Thanks to the characteristics of a standard ship the consumption ranges up to 44 tons of fuel uses per day then the consumption every 24 hours is 508,200 litres. Assuming that 10 bulk carriers will be necessary to transport all the pig iron, the consumption per annum is 5,082,000 litres. Finally it is converting into energy units (Terajoules).

Other consumption includes the energy expended by the trucks which moves the pig iron from the plant to the port. Each truck can carry 10 tons per trip and it does two journeys per day. The total vehicles used by the plant are around 40. The daily consumption will be similar to the Codli mine the only difference is that instead of 1,000 there are 40 trucks which make the fuel consumption lower than Codli mine.

TABLE 4.6: COMPARISON ENERGY USE BETWEEN STEEL PLANT AND EXPORT PIG IRON ABROAD

Activity	Consumption (TJ/yr)	TOE (tn)	CO2 equivalent (tn)
Steel plant	1,640	39,170.73	121,037.54
Exporting pig iron	220.91	5,276.34	16,303.91

The energy consumption of both options has been calculated. The possibility to install and maintain a steel plant is more expensive than exporting pig iron to other countries. Specifically it costs nearly 7.5 times more.

In conclusion, exporting iron will use a larger portion of energy than producing steel but as it is estimated below the best choice for Sesa Goa under terms of energy viability is to continue exporting the iron. However the researchers do not take into account others parameters such as CO_2 emissions or fuel consumption in order to give more parameters to decide which the best option is.

CHAPTER V

ECONOMIC FEATURES

Author: Clara Solé Carbonell

Gross Domestic Production, Exports, Iron ore, Cost Benefit Analysis

INTRODUCTION

In this chapter the economic features from iron mining in Goa are described. There are two different parts. First, an overview of the world iron market, the economy in Goa especially that related to iron mining is presented. Second, the Cost Benefit analysis of iron mining is discussed. An extended research has been made in order to understand the economic context about iron mining. Such research has focused on gathering data, surveys and in depth interviews with people affected by mining. What is the real contribution of iron mining to Goa's GDP? How many tons are exported from Goa? What are the main iron ore companies? Do the social benefits outweigh the environmental cost of the mining industry?

Mining in developing countries is often synonymous to poverty due to the several environmental damages that it causes. Goa which is one of the smallest State of India exports around 50% of the total iron ore exported from the whole country. In this article, an accurate research of Goa's economy and concretely its relation to iron mining is evaluated. Goa is not poor by Indian standards but its relative well-being is due to tourism rather than mining. At that point, Cost Benefit Analysis of iron mining activity in Goa is discussed.

First, although mining and quarrying contribution to Goa's GDP is around 5%, accounting all direct and indirect activities connected to mining activity it is the second most important industry next to tourism. Thus, all economic features such as iron ore production, exports and iron ore companies are analyzed. Global iron ore market and specially India's place on it, iron ore prices and iron ore producing states in India are also described.

Second, monetary valuation of environmental damages due to mining activity is discussed. The lack of environmental studies about social and environmental damages and the difficulty to valuate these impacts in monetary terms make it difficult to evaluate. In the second section of the chapter, different ways to count Employment and mining and quarrying contribution to GDP are described. Then, an accurate Cost Benefit Analysis and various criticisms made by different authors are assessed.

An alternative way of economic activity instead of iron mining is considered and proposed. Regardless the economic growth of Goa due to mining activity, local environmental and social damages from such activity have led to poverty for some people in Goa. In addition, there is a 10-20 year horizon for the reserves (see chapter 1) so the wealth created in Goa because of iron mining will end too. In the recent years, people have become more aware of the social damages from iron mining activity. Consequently they started to fight against mining. They achieved a stop to the activity on October 2012.

1. Global Iron Ore Market and India's place in it

TABLE 5.1: EVOLUTION OF WORLD IRON ORE PRODUCTION (IN MILLION TONS).

Country	2007	2008	2009	2010	2011
China	707	824	880.2	1077.1	1327
Australia	299	343.4	394.1	433.4	488.1
Brazil	354.7	351.2	331	372.3	460.4
India	213.2	213	218.5	208	168.5
Russia	105	99.9	92	95.5	104
World Total	2,052	2,205	2,275	2,620	3,012

Sources: World mineral production and own elaboration.

TABLE 5.2: WORLD IRON ORE IMPORTERS AND EXPORTERS (IN MILLION TONS).

Importers 2011	World imports	Exporters 2011	World exports
China	642	Australia	414
European Union	145	Brazil	324
Japan	133	India	87
South Korea	57	South Africa	52
Taiwan	16	Canada	35
World imports	1,071	World exports	1,071

Sources: UNCTAD and own elaboration.

TABLE 5.3: MAIN IRON ORE PRODUCING COMPANIES (IN MILLION TONS).

Main companies 2011	Production
Vale	310
Rio Tinto	245
BHP Billiton	159

Sources: Company websites and own elaboration.

Almost all of the iron ore produced is used to make steel. Global iron ore production in 2012 was 3,012 million tones with China, Australia, Brazil and India as the main iron ore producing countries. (British Geological Survey, 2011)

Global iron ore production has been increased over the past years. China has been the main iron ore producer in the last years producing around 44% of total iron ore. Indian production has been reduced significantly from 208 Mt in 2010 to 169 Mt in 2011. Thus, Indian contribution to global production was around 8% in 2010 and 5.6% in 2011.

In this project the authors throw light on this various trend in India which continues in 2012, and which is in contrast with the march of many others economic indicators including the extraction of coal which is still increasing over the years. (Index mundi, 2011).

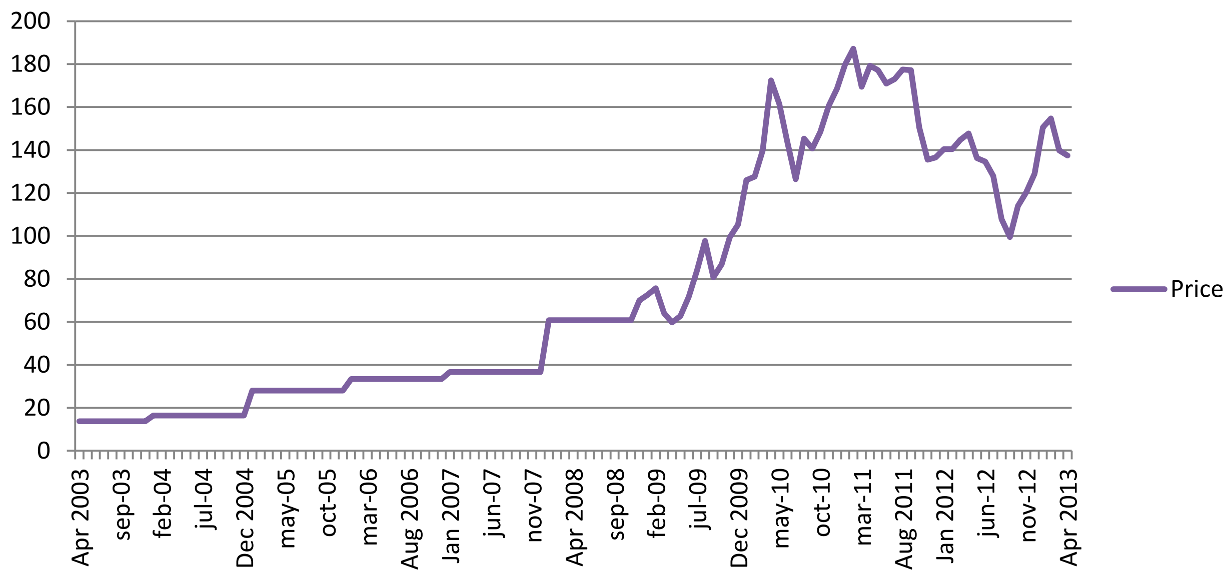
In the last century, after the Second World War Japan was the major importer of iron ore buying 50% of total iron ore exported by all countries. (GMOEA, 2010). Nowadays, due to the rapid industrialization of China, it has become the world's largest producer and consumer of ore, buying around 60% of global iron ore exported.

Australia and Brazil are the top exporters of iron ore, sharing two thirds of total global exporters in 2011. India is placed third as largest exporter, with Indian exports falling since 2009.

In terms of iron ore producing companies Vale SA, Rio Tinto and BHP Billiton control about two-thirds of iron ore supply in the global iron ore market.

1.2. Iron Ore Prices

FIGURE 5.1: IRON ORE MONTHLY PRICES (US DOLLARS PER METRIC TON).



Sources: Index Mundi and own elaboration.

Iron ore prices basically depend on Fe content and transport cost. Historically, global iron ore prices have fluctuated with the global demand for steel and therefore, growing economies and their infrastructure.

In 1960 through 1970s, iron ore prices increased because of the Japanese economic expansion. In that time and over the last 50 years, the main iron ore miners and Japanese steelmakers decided iron ore prices. Nevertheless, with the recent emergence of China it has changed. (GMOEA, 2010).

There has been a tremendous increase in high iron ore prices in the international market in the few last years. In January 2008 prices increased significantly by over 66% from 33.63 $ per dry metric ton in Dec 2007 to 60.80 $ in Jan 2008. This exponential growth in prices is due to the high demand from China in the recent years. Thereafter, during 2009 and 2010 the prices have witnessed fluctuations with different growth and declines.

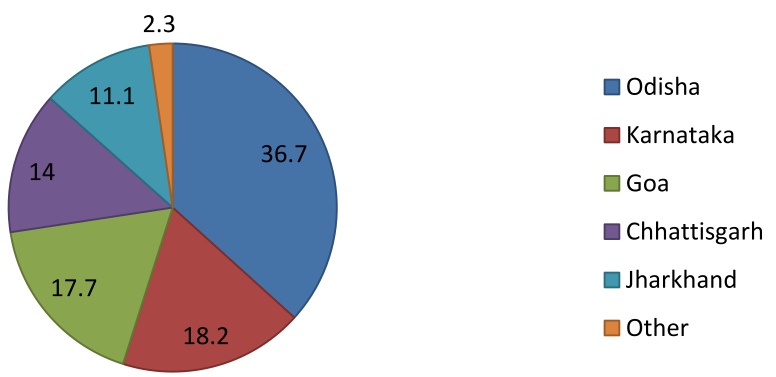
However, since February 2011 prices have decreased and then witnessed various fluctuations due to the slower expansion of steel industry in China and slow industrial activity in Europe and U.S.

2. Iron ore in India

India is the fourth largest producer and the third largest exporter of iron ore. However, this situation has been threatened in recent years by serious environmental damages due to illegal mining.

Odisha is the largest iron ore producer state with a contribution of around 37% of total iron ore produced in India. Karnataka in the second position contributes around 18.2% and finally Goa's contribution is about 17.7%. As we can see in the graphic below, these states are the main iron ore producers in India.

FIGURE 5.2: IRON ORE PRODUCTION BY STATE (2010-11).



Sources: Indian minerals year book and own elaboration.

There have been several environmental restrictions in the recent years in India due to illegal mining. On July 2011 Karnataka government banned all iron ore exports from Karnataka. Then, on 3 September 2012 the Supreme Court allowed a few mines to restart but in certain conditions. Since this happened, other Indian states have witnessed the same situation including Goa on 5th October 2012, Odisha and in a lesser extend Jharkhand.

These mining restrictions on the main largest iron ore producing states and a sharp increase in export duty on iron ore fines have impacted directly on the Indian position in the international iron ore market. Exports which stood at 120 million tons in 2009-10, went down sharply to 61. 8 millions in 2011-12 and are expected to decrease to 15-20 million tons in 2012-13. (Business Standard Newspaper, 2011).

3. Economy of Goa

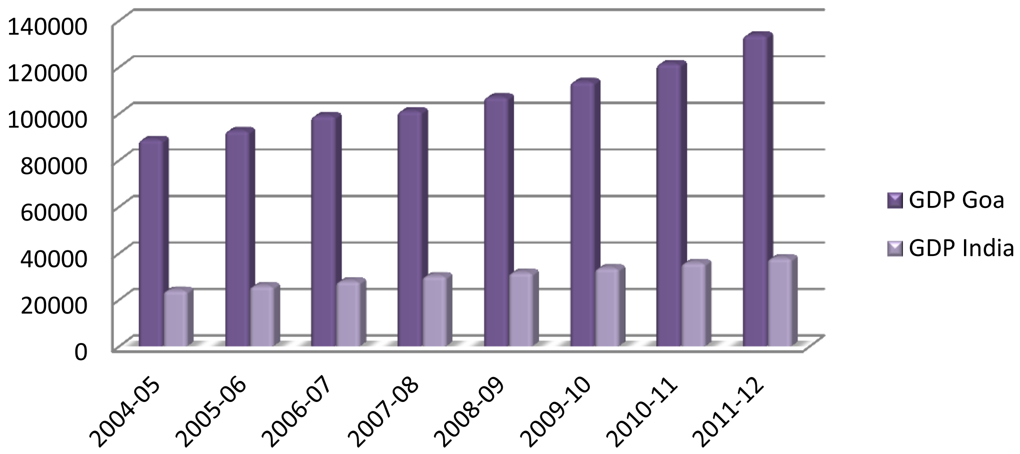
TABLE 5.4: PER CAPITA INCOME OF GOA AND INDIA AT CONSTANT PRICES (2004-05) (IN RUPEES).

Year	Goa GDP	India GDP
2004-05	88,966	24,143
2005-06	92,752	26,025
2006-07	99,154	28,083
2007-08	101,246	30,354
2008-09	107,220	31,801
2009-10	113,828	33,731
2010-11	121,549	35,993
2011-12	133,778	38,005

Sources: Government of Goa and foreign exchange services and own elaboration.

Exchange rate: In 2004 one Dollar equaled 32.15 Rs and in 2012 53.32 Rs.

FIGURE 5.3: PER CAPITA INCOME OF GOA AND INDIA AT CONSTANT PRICES (2004-05) (IN RUPEES).



Sources: Government of Goa and own elaboration.

Goa is one of India's richest states with a GDP per capita two and a half times than the country as a whole.

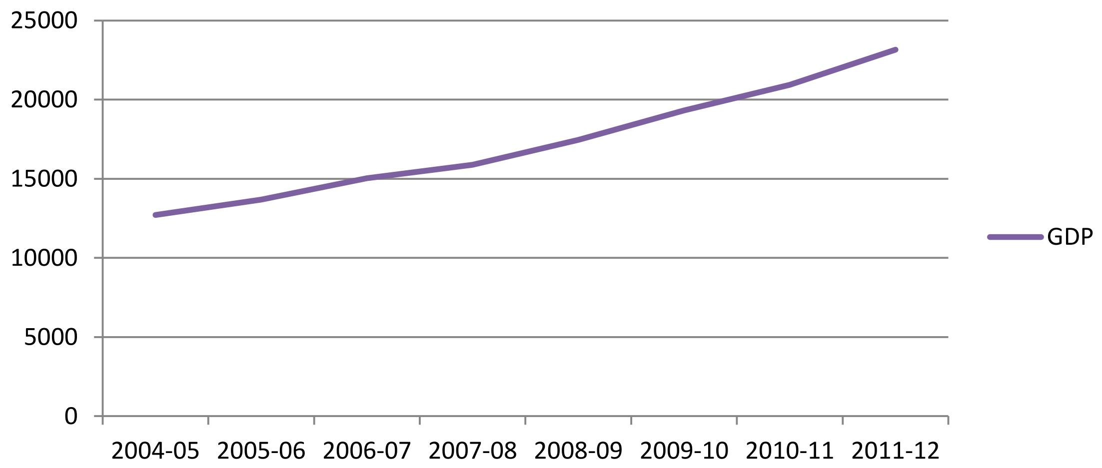
The per capita income of about 130,000 Rs means in dollars about $ 2500. In Purchasing Power Parity (PPP) this would double or more because of the lower price level in Goa (and India) than in U.S. (The World Bank, 2012).

TABLE 5.5: GROSS DOMESTIC PRODUCT (GDP) OF GOA AT CONSTANT PRICES (2004-05) (RUPEES IN CRORES I.E 10 MILLION RS).

	GDP	% Growth over previous year
2004-05	12713	10.19
2005-06	13672	7.54
2006-07	15042	10.02
2007-08	15875	5.54
2008-09	17462	10.00
2009-10	19318	10.63
2010-11	20922	8.30
2011-12	23151	10.65

Sources: Government of India and own elaboration.

FIGURE 5.4: GROSS DOMESTIC PRODUCT (GDP) AT CONSTANT PRICES (2004-05).



Sources: Government of India and own elaboration.

Goa's GDP of the State at constant prices (2004-05) has registered a compound annual growth rate of 9.2% during the period 2000-04 to 2011-12.

TABLE 5.6: GROSS DOMESTIC PRODUCT AT FACTOR COST BY INDUSTRY OF ORIGIN AT 1999-00 PRICES (IN RS. LAKH. ONE LAKH = 100.000).

Sector	1999-00	Share %	2003-04	Share %	2007-08	Share %
Agriculture and Allied	**77,730**	**12.28**	**78,187**	**10.67**	**69,835**	**6.33**
Agriculture	63,726	10.07	55,386	7.56	46,379	4.21
Forestry & Logging	909	0.14	1,151	0.16	1,146	0.10
Fishing	13,095	2.07	21,650	2.95	22,310	2.02
Industry	**244,362**	**38.61**	**314,379**	**42.89**	**455,502**	**41.31**
Mining & Quarrying	26,355	4.16	32,804	4.48	52,953	4.80
Manufacturing	172,442	27.24	226,170	30.86	331,759	30.08

Manu-Registered	144,621	22.85	191,410	26.12	279,896	25.38
Manu-Unregistered	27,821	4.40	34,760	4.74	51,863	4.70
Construction	35,108	5.55	39,244	5.35	52,004	4.72
Electricity, Gas & Water Supply	10,457	1.65	16,161	2.20	18,786	1.70
Services	**310,883**	**49.11**	**340,372**	**46.44**	**577,426**	**53.36**
Transport, Storage & Communication	60,993	9.64	99,770	13.61	25,7442	23.35
Railways	2,061	0.33	2,953	0.40	8,018	0.73
Transport by other means	55,705	8.80	90,001	12.28	178,711	16.21
Storage	285	0.05	357	0.05	463	0.04
Communication	2,942	0.46	6,459	0.88	70,250	6.37
Trade, Hotels & Restaurants	96,300	15.21	73,257	9.99	77,771	7.05
Banking & Insurance,	53,670	8.48	62,343	8.51	117,902	10.69
Real Estate, ownership of dwellings and Business Services	37,564	5.93	46,493	6.34	60,766	5.51
Public Administration	34,184	5.40	29,414	4.01	30,253	2.74
Other Services	28,172	4.45	29,095	3.97	33,292	3.02
State domestic product	**632,975**	**100.00**	**732,938**	**100.00**	**1,102,763**	**100.00**

Sources: Government of India and own elaboration.

The tertiary sector dominates the economic structure of Goa, followed by the secondary and the primary sector.

Agriculture dominates the primary sector while mining and quarrying are the second most important in this sector. As we can see in the table above, agriculture and fishing are the only sectors that have reduced significantly over the years. At the same time, there has been a decline in the land under cultivation in the mining region while mining has been increased.

On the other hand, iron ore comprises a share of 93% to 94% in total mining and quarrying sector (GMOEA, 2006). The iron ore industry also comprises part of the transport sector. A part from extraction other activities like manufacturing or transport are connected to mining activity. If we account these direct and indirect activities, iron ore industry is the second most important industry next to Tourism.

The tertiary sector dominates the economy over 50% of the State Domestic Product originating in this sector. Tourism is most definitely part of this sector. Goa is visited by hundreds of thousands of international and domestic tourist each year.

Mining has been an important element of the economic history in Goa. It started in 1950 and has played a key role in the development of Goa's society.

4. Iron ore in Goa

Goa's iron ore industry is 100% oriented to exports. Goa exports around 50% of iron ore in India. However, in value terms its contribution it is not so high due to the low prices of low grade iron.

Goa's iron ore has a low grade; the content of Fe is around 58% to 62%. This iron has to go in an elaborated process of beneficiation and concentration in order to increase the grade and make iron more attractive to export.

Goa has a positive logistics infrastructure such as navigable rivers, ports and natural harbors. These factors have played an important role to understand the emergence of Goa as an important exporter of iron ore. This is because the cost of transporting ore by barges and ships to nearby export harbor is cheaper than railways and, thus, it provides cost competitiveness to export of even low grades of iron ore.

There is only one pig iron plant that uses the iron extracted; the rest is all exported abroad.

4.1. Iron Ore Production

TABLE 5.7: IRON ORE PRODUCTION (IN TONS).

Fiscal year	Production
2002-03	17,371,039
2003-04	23,727,936
2004-05	21,705,667
2005-06	25,440,925
2006-07	30,738,191
2007-08	30,997,000
2008-09	31,195,000
2009-10	38,136,000
2010-11	36,723,000

Sources: GMOEA and own elaboration.

Iron Ore production has increased since 1970 and especially in the last five years. As we can see in the table above, production in 2009-12 was around twice the production in 2003-04. This growth of mining is due to the high demand from China, the main consumer of Goa's iron ore. On the other hand, Goa's contribution to iron ore global production is around 1.2%.

4.2. Iron Ore Exports

All of Goa's iron ore is exported so there is no local market for its low grade ore. Goa is the biggest exporter of iron ore in India and it accounts for almost 50% share in the total ore export of India. The iron which is exported from Goa comes mainly from Goa but also from Karnataka which is called Non-Goan iron ore in the table 5.8. below.

Iron ore exports started in Goa in the late 40's with around 30-40 thousand tons of iron exported through Mormugao Port. The exports increased up to an average of 10 million tons in 1971, a maximum of 14 million tons in 1985 and have been rising consistently since then until 2012. (GMOEA, 2006)

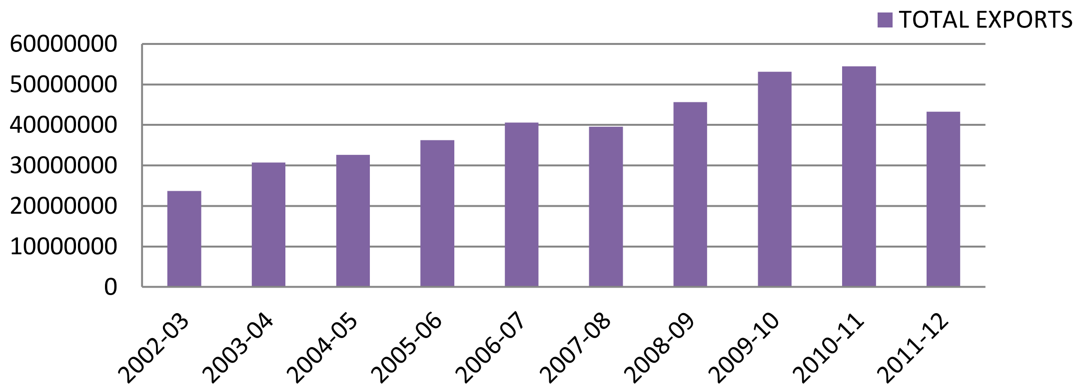
TABLE 5.8: IRON ORE EXPORTS FROM GOA. (IN TONS).

FISCAL YEAR	GOAN IRON ORE	NON-GOAN IRON ORE	TOTAL EXPORTS IRON ORE
2002-03	18,858,230	4,762,732	23,722,880
2003-04	22,095,993	8,628,647	30,724,640
2004-05	23,308,033	9,280,138	32,588,171
2005-06	25,537,924	10,733,726	36,271,650
2006-07	30,893,953	9,642,721	40,536,674
2007-08	33,434,429	6,117,626	39,552,055
2008-09	38,075,223	7,513,548	45,588,771
2009-10	45,686,900	7,445,102	53,132,002
2010-11*	46,846,383	389,219	54,424,849
2011-12**	38,252,554	450,343	43,279,347

***7,189,247 ** 4,576,450. These are un-classified by GMOEA and have to be added to get the total iron ore exported in 2010-11 and in 2011-12.**

Sources: GMOEA and own elaboration.

FIGURE 5.5: TOTAL IRON ORE EXPORTS FROM GOA



Sources: GMOA and own elaboration

Iron ore export volumes have increased dramatically over the years. However, due to the ban of all iron exports in Karnataka on July 2011 and logistics constrains in Goa, iron ore exports volumes in Goa have decreased from 2010-11 to 2011-2012. Then, in late 2012 iron ore extraction was banned in Goa.

Goan iron ore exports contribution in the global iron ore export trade was around 5.1% in 2010-11.

TABLE 5.9: EXPORTS OF IRON ORE FROM GOA BY COUNTRY OF DESTINATION. (IN TONS).

YEAR	CHINA	JAPAN	SOUTH KOREA	PAKISTAN	RUMANIA	NETHERLANDS	OTHERS
2007-08	30,712,595	4,826,305	1,265,108	913,377	810,100	658,250	366,320
2008-09	39,823,961	3,706,884	653,560	356,700	344,200	296,500	406,966
2009-10	47,533,430	3,686,200	1,029,195	80,850	161,900	477,097	163,330
2010-11	48,935,697	3,472,251	1,091,828	83,433	159,430	484,600	197,610

Sources: GMOEA and own elaboration.

The mainly buyer of Goa's iron ore has been China in the last years. Apart from China, other important consumers are Japan, South Korea and some European countries. In 2010-11, China was the main country of destination with around 90% followed by Japan with 6.4% and South Korea with 2% in the third position.

4.3. Main iron ore companies in Goa

Sesa Goa which belongs to Vedanta is the main iron ore producer and exporter company from Goa. Apart from Sesa Goa which produces almost 50% of Goan iron ore, there are other important firms like Fomento, Salgaocar, Timblos and Chowgule. However, it seems that Sesa Goa is the only company that has the annual report available.

Sesa Goa

Sesa Goa founded in 1954 is a part of London-listed Vedanta Resources. The company acquired Goa-based Dempo group's mining and maritime business on June 2009.

Sesa is the India's largest producer and exporter of iron ore in the private sector. The company operates in the states of Goa and Karanataka in India and they have a Liberian iron ore project in Africa.

Sesa also produces pig iron and metallurgical coke that operate as an independent business division.

TABLE 5.10: PRODUCTION IN EACH BUSINESS SEGMENT

Production	2009-10	2010-11	2011-12
Iron ore (mt*)	19.2	18.8	13.8
Pig iron (kt)	280	276	249
Met Coke (kt)	262	263	257

***mt – million tones in dry metric tones**

Sources: Sesa Goa Sustainability and own elaboration.

In 2009-10 Sesa Goa production accounted for 50% share in the total iron ore produced in Goa. Nevertheless, compared to the last year, the productions and sales volume have decline dramatically due to the ban on mining in Karnataka and silogistic constraints in Goa. According to Sesa Goa about 35% of Goa's revenue disappeared since the iron ore industry in the state was ordered to be closed.

Moreover, the total Sesa Goa Economic value added in 2009-10 was Rs 2,398 Crores and in 2010-11 was Rs 3,965 Crores, approximately worth of $ 800 million (Sesa Goa, 2012).

TABLE 5.11: EXPORTS OF GOAN IRON ORE BY COMPANY. (IN TONS)

Company	2007-08	2008-09	2009-10	2010-11	2011-12
Sesa Goa	7.529.441	10.210.820	16.009.243	15.947.886	14.931.779
Dempo	3.644.954	4.347.543	-	-	-
Fomento	2.496.103	4.113.366	5.380.973	11.792.845	7.840.471
V.M Salgaocar	4.202.110	3.757.920	5.479.285	4.733.373	3.945.354
Chowgule	3.071.271	3.313.184	3.325.788	2.636.637	2.916.891
Others	12.490.551	15.332.390	18.491.607	11.735.642	8.618.059
Total	33.434.429	38.075.223	45.686.900	46.846.383	38.252.554

Sources: GMOEA and own elaboration

From 2009-10 until 201-12 Dempo’s company does not have exports because it was acquired by Sesa Goa. Consequently, Sesa Goa has increased its exports since June 2009.

Sesa Goa limited together with V.S. Dempo & Co Limited which is a part of the company, exported 16,009,243 tons of Goa’s iron ore during 2009-2010. This is around 35% of total Goan iron ore exports.

5. Cost Benefit Analysis

On this section the researchers analyze the Social Cost Benefit analysis done by the National Council of Applied Economic Research (NCER) and different criticisms made because of the methodology, the data base that they used for their results and the quality of this information.

Mukhopadhyay P. and Kadekodi G. with their article “Missing the Woods for the Ore: Goa’s Development Myopia” have criticized “A study of Goan Iron Ore Mining Industry”, the 2010 report done by NCAER. Then, Basu R. wrote an article to provide some information that the MG’s critique omits. After that, R Venkatesan who is a senior consultant at NCAER published an article as a response to the two criticisms. Finally, Basu R. sums up the NCAER report, the criticisms and the response. All these articles are published in the influential journal Economic and Political Weekly.

The authors attempt to do an accurate analysis of these articles in order to see the different parts that they discuss and create an opinion about that. After a detailed reading of these articles we have tried to summarize the main issues with the different results obtained in each part. Before the social cost benefit analysis, the researchers have studied different previous issues such as employment in iron mining and mining contribution to GDP.

5.1. Cost Benefit Analysis and Multi Criteria Evaluation

Cost Benefit Analysis (CBA) is the world most used methodology to quantify in monetary terms cost and benefits of a decision, program o project in order to get a single scale of comparison for all the elements implicated. CBA attempts to measure the monetary value of all costs and benefits that are expected to result from the activity which is evaluated including positive and negative externalities. Environmental costs cannot be easily quantified in money terms. According to this, there is an increasing economic literature which is focused on finding ways to attach dollars values to these variables.

The goal of CBA is to determine whether the net impact of a project is positive or negative by using the Net social Benefit (NSB) which calculates the excess of total benefit over total cost. The NSB is represented by the Net Present Value (NPV) which is calculated by applying a certain discount rate to identified costs and benefits due to people time preference and money uses in the future. Another fundamental concept in CBA is the opportunity cost: the cost of using a resource is the cost of forgoing the best alternative use.

Multi Criteria Evaluation (MCE) is another decision-aid tool used to evaluate acceptable alternatives for a decision, program or project. This methodology in contrast to CBA, is a non monetary approach because it allows to take into account several criteria and the stakeholders' opinions. The indicators of the attributes specified in the Multi Criteria Evaluation must be identified. The measurement of these indicators is often based on scoring, ranking and weighting of a wide range of qualitive categories and criteria.

5.1.1. NCAER Results

NCAER published a study carried out using a social cost benefit analysis to analyze the social benefits obtained from iron ore and to evaluate the social costs associated with this industry.

The main results obtained from this study are in the table below:

TABLE 5.12: EMPLOYMENT IN IRON MINING AND MINING CONTRIBUTION TO GDP

Employment in iron mining	➢ **Direct:** 19,000 (year 2004-05) ➢ **Indirect:** 60,000 (year 2008-09)
Mining contribution to GDP	16.94% (year 2008-09)

Source: NCAER and own elaboration

TABLE 5.13: SOCIAL BENEFITS

Social Benefits (year 2008-09)	Value (Crores Rs)
9.9% (the weighted tariff of imports in India) of total exports (Rs 9,172.95 Crore) of iron ore from Goa	908
Carbon credit	10.9
Subsidy saved on diesel	30.6
Tax paid to state Government	
Royalty paid at 10% ad valorem tax	300
Barge tax	12
Road infrastructure cess	50
Central taxes	
Cenral government includes export duty at 5% towards fines and10% to lumps	250
Corporate income tax differentials	748
Total Benefits	**2,309.5**

Source: NCAER and own elaboration

TABLE 5.14: SOCIAL COST

Social Costs (year 2008-09)	Value (Crores Rs)
Unaccounted Cost of landfill sites	14.1
Avoidance cost for the solid waste management:	0.5
Air pollution	66.5
Deforestation cost	467.3
Total environmental Costs	**548.4**

Source: NCAER and own elaboration

Net Social Benefit (NSB) = 1842.2 Crores

The costs associated with giving up the iron ore industry in Goa (Opportunity Cost) would be grater by Rs 1,842.20 Crore per year than costs to the environment associated with running the industry.

Net Present Value (NPV) = Rs 14,499 Crores

The Net Present Value of the opportunity cost (for 25 years at 12% social discount rate) of giving up the iron ore industry is greater than the environmental cost of the iron industry by Rs 14,449 Crores.

5.1.2. Criticisms

Employment in iron mining

The NCAER report claims that mining and quarrying industry is one of the largest employment generators in Goan Economy. They calculated that total direct and indirect employment due to mining and quarrying in 2008-09 were 75,000 employees. From this 45,000 were employees in transport specific due to mining and quarrying, 15,000 were direct employments and 15,000 were indirect employments (Trade, Hotels & Restaurants, ship agents, international business, etc). Thus, according to NCAER transport related on iron mining generates more employment than concretely mining and quarrying sector. They also states that direct mining employment in 2004-05 was accounted to be 19,000 employees out of a total labor force in Goa of 582,000.

Basu R. in response to NCAER report did his own calculation and suggested that the total employment in 2008-09 would not exceed 21,873. He calculated direct employment which was accounted to be 5,416 and estimates that indirect employment to be 5,500 (including transport specific to mining and quarrying).

Other surveys like National Sample Survey report, calculated that the direct mining employment in 2004-05 would be 6,000.

The Fifth Economic Census in 2005 reports that people usually working in Goan mining is 3,412 plus 3,161 hired workers, with a total of 6,573 direct employments.

According to Rahul Basu calculations, National Sample Survey report and the Fifth Economic Census direct employment due to mining and quarrying in Goa are around 6,000 workers instead of 19,000 as NCAER report said. Besides, if we compare Basu R. calculations for indirect employment (including transport related on mining) with NCAER report, it can be concluded that NCAER has overestimated both direct and indirect employment.

TABLE 5.15: EMPLOYMENT IN IRON MINING

Year 2004-05	NCAER	Rahul Basu	NSSO	Fifth Economic CENSUS
Direct employment	19,000	5,416	6,000	6,000
Indirect employment	60.000*	5,500	-	-

*Year 2008-09

Source: NCAER and own elaboration

Mining contribution to GDP

The share of mining and quarrying sector is quite different when measured at constant 1999-00 prices and at current prices. The share to GDP when measured at constant 1990-00 prices increased from 4.2 percent in 1999-00 to 4.5 percent in 2004-05 and further to 4.8% in 2007-08. However, at current prices the share jumped up to 16.94 percent in 2007-08 due to the sudden increase of iron ore prices in the international markets during January 2008 when prices increased by over 65% from 33.63 $ per dry metric ton in Dec 2008 to 60.80 in January 2008.

NCAER calculate that mining contribution to GDP is about 16.94% assuming that high iron ore prices will be permanent over the years. Nevertheless, as Basu R. says in his critique, this assumption is too optimists as commodity prices are cyclical and higher prices don't be permanent. R Venkatesan in the rejoinder justify his calculation by saying that mining and quarrying contribution to GDP is the same as economic survey 2008-09 wrote using 2008-09 prices as border prices, just when the prices increase significantly.

Basu R. in response wrote that NCAER report omits all the published information around the expected and current iron ore prices and its tendency. NCAER has fixed his attention only in 2008-09 economic priced and has done its GDP contribution ignoring all the information that conduces in a tendency of 5%.

According to our research international iron ore prices increase in January 2008. However, prices witnessed fewer fluctuations with various growth and declines in previous and next years. Moreover, since February 2011 prices have decreased due to the slower expansion of steel industry in China and slow industrial activity in Europe and U.S. Hence, as Basu R. claims prices are cyclical and a permanent tendency about 5% of Goan GDP is more realistic.

Social Cost Benefit Analysis

According to the NCAER report, the benefit generate from iron mining in Goa are the revenue created from mining on the one side and the social benefits in the other. However, the report has focused on the social benefits and cost of iron mining.

Social Benefits

- **The foreign exchange earned due to the exports of iron ore produced in Goa**: it is estimated to be 9.9% (export duty) of Rs. 9,172.95 Crores (worth of exports), it is **Rs. 908 crores**
- **Taxes paid to State and Central Government by the mining industry:** the report accounts a significant iron ore contribution to State and Central Government revenue in the form of taxes. According to the NCAER In 2008-09 the taxes were:

TABLE 5.16: STATE GOVERNMENT TAX

State Government	
TAX	Amount (in Crores)
Royalty paid at 10 ad valorem tax	300
Barge tax	12
Road tax	12
Road infrastructure	50
VAT, CST	50
Others (Minor port, Surface rent)	76
Total	**500**

Source: NCAER and own elaboration

TABLE 5.17: CENTRAL GOVERNMENT TAX

Central Government	
TAX	Amount (in Crores)
The includes export duty at 5% towards fines and 10% to lumps	250
Corporate Tax	1,600
Major Port Charges	150
Total	**2,000**

Source: NCAER and own elaboration

Taxes from mining and quarrying

The total receipts of Goa's government for year 2008-09 on tax revenue was **Rs. 2,109 Crores**. From this, the net corporate tax benefit due to mining and quarrying industry was **Rs.748 Crores**. Thus, in 2008-09 the net corporate tax benefit due to mining and quarrying industry was a share of 35% of total government tax revenue.

Mukhopadhyay P. and Kadekodi G. noticed that some taxes accounted on the NCAER report don't represent the real environmental cost that they create. For example, it is not clear that a barge tax and Road tax of Rs 12 can compensate the damage they originate.

R Venkatesan in response to that statement wrote that the government has the responsibility to fix this so that a fixed tax of 12 Rs has to be appropriate.

The researchers cannot be confident about the data base published from the government as a lot of different data is published about the same aspect. Thus, a scientific survey is required in order to know the real environmental damage originated from barges and trucks.

Double counting

Another point that Mukhopadhyay P. and Kadekodi G. noticed is the fact that the taxes have already been added in the iron ore prices. Moreover, the royalty paid by the firms are accounted as a net benefit to society when the royalty paid by firms is supposed to be de cost of depletion natural resource.

R Venkatesan in response said that taxes and cess cannot be exported abroad and they have to be counted as a benefit to society. About the royalty paid by firms, R Venkatesan claims that because of the low grade of Goan iron ore a depletion price is not warranted. However, as Basu R. wrote low grade is not zero value.

The Researchers think that both this double accounting and the royalty accounted as a social benefit have to be reviewed and no overestimated.

Carbon Credit and diesel subsidy Benefit

NCAER noticed that the firms are doing an additional effort with the transportation of the iron ore by barges and ships instead of being transported by train. Consequently, this contributes a less emission of CO_2 so this effort for no polluting has to be translated into carbon credit benefit. This effort is estimated to be **Rs 10.9 Crores** of carbon credit due to fuel saved and **Rs 30.6 Crores** of diesel subsidy saved due to fuel saved by iron mining industry.

However, as Mukhopadhyay P. and Kadekodi G. explain the firms have not done an effort to reduce polluting. The reason why they chose to transport iron ore by ships is because it is cheaper than being transported by train. So these carbon credits are neither an additional benefit nor fuel saved.

R Venkatesan in response states that just because of the less polluted option is the cheapest way to transport iron ore this have not disqualify these carbon credit and fuel saved.

The researchers think that all iron is exported from Goa to abroad by ships because it is the best way for firms to get more benefits. Thus, this carbon credit must not be seen as a social benefit since it is not an additional effort to reduce pollution. Moreover there is also a question on the "price" of carbon credit, which is now very cheap.

TABLE 5.18: TOTAL BENEFITS

Benefits (year 2008-09)	Value (Crores Rs)
9.9% (the weighted tariff of imports in India) of total exports (Rs 9,172.95 Crores) of iron ore from Goa	908
Carbon credit	10.9
Subsidy saved on diesel	30.6
Tax paid to state Government	
Royalty paid at 10% ad valorem tax	300
Barge tax	12
Road infrastructure cess	50
Central taxes	
Cenral government includes export duty at 5% towards fines and10% to lumps	250
Corporate income tax differentials	748
Total Benefits	**2,309.5**

*The NCAER have excluded the road tax and have incorporated the corporate tax differentials to account for benefits that are due to mining industry.

Source: NCAER and own elaboration

Social Cost

Avoidance cost for the solid waste management

The NCAER report calculated a cost of 0.45 Crores. However, as Basu R. claim in his critique it is only for municipal solid waste. He estimated a cost of Rs. 20,421 Crores per annum of solid waste management.

TABLE 5.19: SOCIAL COSTS

Costs	Value (Crores Rs)
Unaccounted Cost of landfill sites	14.1
Avoidance cost for the solid waste management:	0.5
Air pollution	66.5
Deforestation cost	467.3
Total environmental Cost	**548.4**

Source: NCAER and own elaboration

Air pollution

NCAER has calculated the cost of air pollution assuming a set of statements that are controversial. They said, the industrial pollution had a cost of Rs 517 Crores in 2008-09 and air pollution due to iron mining is roughly 10% of total industrial air pollution in Goa. They calculated this 10% assuming that the mining industry only occupied less than 3% of the total area in Goa and the pollution caused by industries in an area can't exceed more than three times the area they occupied.

As Mukhopadhyay P. and Kadekodi G. states in their article, these assumptions has not make sense because different reasons; First the area occupied by the industry is need not have a link to the amount of pollution it causes, Secondly the NCAER report does not say how it arrives at estimate of 3%, finally the pollution generated by mining is not limited to the area around mines because it also spreads during transportation and industries. Hence, the researches thing that probably the pollution created by iron mining exceed this 10%.

Deforestation cost

The NCAER report adapted forest values generated by IRADE (2008) using Verma (2000) methodology, assume that the Total Economic Value (TEV) of Goa forest comes out to be Rs. 2925.93 Crores. Thus, the total economic value less indirect benefits was **Rs. 363.26 Crores** in 2004-05 and **Rs 467.62 Crores** in 2008-09. This is around a worth of 2.6 billion dollars and 3.98 billion dollars respectively. According to NCAR the corresponding deforestation cost due to mining is estimated to be Rs 1.58 lakhs per hectare of forest area at 2008-09 prices which is a worth of 134800 $ per hectare. These values are calculated using 1424 square kilometers of dense forest area and about 296 square kilometers under mining. Moreover, the economic value of Goa forest has been calculated less the indirect benefits of watershed, eco-tourism, Carbon sink and Fodder (70%).

Muckhopadhyay P. and Kadekodi G. in their article "Missing the Woods for the Ore: Goa's Development Myopia" states that NCAER report undervalues the environmental costs of mining and overvalues the benefits in their calculations. NCAER report accounts only direct environmental cost such as air pollution, water pollution, impacts on land and deforestation, ignoring the entire loss of ecosystem service. However, in order to get an accurate TEV, use (direct and indirect) and "non use" benefits from ecosystems have to take into account.

The IRADE and corresponding NCAER arrived at much smaller values for Goa's forests than estimates by the Green Accounting for Indian States Project (GAISP), namely Gundimeda et al (2005,2006,2007) and Kumaret al (2006) as well as the ones form Supreme Court (2008).

GAISP and Supreme Court methodologist are the only ones that account non-use values and resilience value so they arrive at much bigger forest values than IRADE and NCAER. IRADE and NCAER may have undervalued some of the benefits from forest. Moreover, IRADE and NCAER ignore the benefits from parks and sanctuaries in ecotourism benefits. Biodiversity benefits are also accounted different depends on the methodology that they use. Basu R. in his article, add that NCAER has ignored the study done by TERI on the impact of mining in the society and health in the mining belt.

Value of Net Benefits of iron ore industry

Net Social Benefit (NSB) = 1842.2 **this calculation has to be review because it only has counted deforestation cost and not the total environmental cost.* Anyway, we assume that the net benefit is about **Rs 1842.2 Crores per annum**. According to the NCAER report, the social benefits outweigh the environmental cost of the mining industry. And thus, mining should continue to operate in Goa.

TABLE 5.20: TOTAL ECONOMIC VALUE (TEV)

	IRADE		NCAER		GAISP		Supreme Court
	Total Economic	Economic Value	Total Economic	Economic Value	Higher Bound	Lower Bound	
2001-02 prices					16,988	10,878	
2004-05 prices	4,430	550	2,925	363			
2008-09 prices							18,606
2009-10 prices	5,454	677	4,067	505	27,617	17,684	21,027

Source: NCAER and own elaboration

Net Present Value (NPV) = Rs 14,499 Crores

The NCAER calculate the NPV assuming the same net benefit every year for the next 25 years and a discount rate of 12%.

However, according to Mukhopadhyay P. and Kadekodi G. calculations if mining were until 2017 (nine years horizon) the gross present value of benefits for the mining sector would be 17,833 Crore (with a 5% SDR) or 13,049 Crore (for 12% SDR).

Opportunity cost

Costs associated with giving up the iron ore industry in Goa (Opportunity Cost) would be greater by Rs 1,842.2 Crore per year than costs to the environment associated with running the industry. Assuming the same net benefit every year for the next 25 years and a discount rate of 12% the Net Present Value of the opportunity cost of giving up the iron ore industry is greater than the environmental cost of the iron ore industry by 14,449 Crores.

The assumptions used by the NCAER report to calculate the NPV have been criticized by Mukhopadhyay P., Kadekodi G. and Basu R.

First, there is a controversial opinion of the estimate on iron ore reserves in Goa and the annual rate which it is extracted. Mukhopadhyay P. and Kadekodi G. cast doubt on the 25 year horizon for the reserves to end. According to the Geological Survey and the annual rate of extraction NCAER this forecast is too optimistic. They suggest that we should take into account a period of eight or nine years for the reserves to end.

Second, the social discount rate (SDR) of 12% used to calculate de Net present Value has also been criticized. The NCAER justify this SDR by saying that it is the rate generally used to evaluate projects by international and national agencies.

Mukhopadhyay P., Kadekodi G. and Basu R. claim that as environmental valuation is concerned, SDR used typically is between 0% and 5% range.

The researchers state that there is no professional consensus about what is the correct discount rate that should be used and therefore discounting has been a controversial subject.

Discounting the future means valuing costs and benefits from future generations less than the current costs and benefits. A high discount therefore implies less value to future generations. The Economy justifies this discounting with the uncertainty, the growing wealth, human preferences and social opportunity cost. However, for some authors the use of a positive social discount rate is incompatible with the intergenerational equity. In this sense, there is extent environmental literature in favor of using a lower discount rate or even a zero SDR.

The most controversial valuation had been the value of unspoiled natural environments. In this context, there is an interesting contribution of Krutilla who modified cost-benefit analysis in order to give more weight to natural amenities. (Martinez-Alier, 1994).

The researchers think that a lower SDR from 0 to 5% should be use when we take into account future generations and if we want to preserves resources in a sustainable way. We consider that the SDR which has been chosen by the authors is important because it can changes significantly the result of the Net Present Value and therefore the best alternative that should be chosen.

The Cost Benefit Analysis done by the NCAER has been criticized by different authors due to the lack of scientific studies and the controversial assessment when measuring externalities in monetary terms. According to these authors and the study done by the researchers, there are too many evidences to cast doubt on the results from NCAER which states that social benefits outweigh the environmental cost of mining industry.

7. Highlights

The State of Goa which is the third iron ore producer in India, contributes about 50% of total Indian iron ore exports. In addition, India is placed third as largest iron ore exporter in the global market. Thus, there is an important contribution to Goa exports in the Indian and the global trade of iron ore.

The State of Goa with a GDP per capita of two and a half times that of the average for the country as a whole is one of the smallest and richest states of India. Tertiary sector dominates the economic structure of Goa, followed by the secondary and primary sector in the third place. Hence, the tertiary sector and concretely tourism is the most important industry in Goa followed by Iron Ore industry in the second place. Mining and quarrying sector only contributes 5% of Goa GDP. However taking into account direct and indirect activities such as transport its contribution to GDP is even higher. Moreover, traditional activities like agriculture or fishing have been decreasing over the past years because of the harmful damage due to mining activity.

Iron ore which comprise a share of 95% of total mining and quarrying sector is 100% oriented to exports with China as the main buyer. The exports which have been rising since 1970 with an amount of 10 million tones have been increasing dramatically since then with 54.5 million tons in 2010. However, since the ban in iron ore exports in Karnataka on July 2011 and constrains in Goa, the exports have began to decrease since 2010.

Sesa Goa which is the main iron ore producing company exporting about 50% of Goan iron ore, produces about 35% of total iron from Goa. However, the firm has also other mining projects in Africa in order to continue exploiting when the reserves in Goa are depleted.

Since iron mining industry has been important in Goa and iron is an exhaustible resource, other way of thinking is necessary to find other alternatives for the development of Goa like using opportunities of eco-tourism, recreation, fishing or traditional medicines. Goa has the enough wealth to growth in a sustainable way. It can be inferred that NCAER has underestimate the ecological capital of Goa and overestimate the value of mineral resources. Moreover, scientific studies are required in order to do an accurate analysis of the huge damages due to mining in Goa.

CHAPTER VI

POLICY AND MANAGEMENT

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Policy, Mining Lobby, Environmental Management, Mine Leases, Regional Planning, Environmental Clearance and Stakeholder.

INTRODUCTION

In the last chapter of the diagnosis, the iron mining issue of Goa has been analysed through a political perspective. The description of environmental policy and management scene has the aim to explain the causality of the current iron mining ban imposed by Supreme Court due to the irregularities found by Justice M. B. Shah Commission.

First of all, it is explained the origin of the contemporaneous policy system in Goa and its mining lobby. Thereafter, the description about the evolution of Eco development regional planning and the environmental policy and law which pretends to show the diverged vision between different social sectors and, at the same time, how the ecological perspective is appreciated (or not) by the decision-makers in comparison with private mining interests. For example, it has been noticed how the mine leases used to be traded and granted by the former Portuguese regime whose Mining Concession Rules are still valid.

In order to know which the stakeholders are involved in the iron mining ban, a Venn diagram has been made so the main protagonists of the environmental conflict can be easily identified.

Finally, the researchers have found ten clues for the purpose to explain the reason why the mining business became out of control and, above all, which reasons caused such a drastic decision of Supreme Court.

1. History of the iron ore mining management and law

1.1. Portuguese iron mining management

The iron mining industry in Goa had already started 70 years before. In fact, the craft extraction of that ore began at the Neolithic age and got a boost during the Buddhist period. In the seventh century many caves (located most of them in Lamgao, Bicholim and Rivona) were used for smelting iron. Even more, in order to do those tasks, there were the iron artisan's class called "dhavads", who used to smelt the iron.

In the16th century, the Dutch John H.V. Linschoten confirmed the presence of iron ore in Goa. In his publication, "A historical and Archaeological Sketch of the city of Goa" (1878) he already said that there could be found stones containing iron. However, he argued that the government authorities should not permit the extraction and export of the same (Digital Goa, 2010).

Nevertheless, several centuries later, in 1905, the iron mining business became when a French company called "Compagnie de Mines de Fer de Goa" made the first prospection of iron ore deposits in Bicholim. The British Geological Survey of India also visited Goa in 1909. So that, the Portuguese rulers of that time were aware of such treasure and commissioned Dr. Oertal, a German geologist, in order to design a geological map of the most potential mine areas. (Alvares, 2002)

The Portuguese decree, dated on September 20th 1906, is the basic law granting mining concessions in Goa. The main features of concessions under the decree were:

- The concession was given in perpetuity with the government's role restricted to exercising supervision over the extraction of ores.
- The right to a mining concession was also recognised as a patrimonial right under the Portuguese constitution.

In 1947 the first mine concession was given by the Portuguese government. Such mining concessions were granted to around 600 private parties. Therefore, the land was parcelled out by all the powerful families of the territory in order to remove the Common land rule that existed since the arrival of the first Portuguese rulers. Thereafter those few families like the Chowgules, the Dempos, the Salgaocars and the Timblos started through mining, although nowadays they do not completely depend on that industry. (Alvares, 2002)

The main reason of the sudden emergence of that business is maybe the fact that Portugal was officially neutral during the Second World War, in spite of the sympathies that the Portuguese had for the Nazis. The British government imposed many restrictions in the trades between Goa and the rest of India because England was in favour of the Allied Forces (they also had their historical interests in that territory). Those restrictions caused several impacts on Goan’s economy. In that context, prospection of iron and manganese became rapidly a great business and the mining concessionaires turned rich overnight, while the village people, who used to work in their lands, had no other option but working on mines. In fact, the traders and mining concessionaires, along with the help of the government, tried to maximize the profits of the ore exportation and the importation of any kind of goods. (JF Gomes, 2002)

During that time there was another important reason for the improvement of the iron extraction and exportation from the Western Ghats mines. After the Second World War, Japan was an enormous demand of iron for their shipping industry. The Japanese Empire had lost almost all their fleet in the War so they needed iron and steel to rebuild the country. Hence, Goa became one of the most important iron exporters of the Japanese market, supported by the U.E.A. who pretended to help Japan to get over after the tragic ending of that country. (JF Gomes, 2002)

1.2. The new independent Goa. The Indian new administration

In 1961 Goa was democratically liberated by the British so this land was included in the new Indian boundaries. Thereafter, the mine owners asked to the International Court of Justice at The Hague if Goa was "captured” or “liberated". The government of India allowed to let it termed as "liberation", so the rights of the mine owners of carrying on the mining concessions granted by the Portuguese were not abolished (Alvares, 2002). The new Goa government made several unsuccessful attempts to cancel the mining Portuguese concessions. Finally, Parliament enacted the Goa, Daman and Diu Mining Concessions (Abolition and Declaration as Mining Leases) Act, in 1987, to abolish all the old mining concessions and to treat them as mining leases under the corresponding Indian law, with retrospective effect from December 20, 1961. The total number of leases granted under the Act was approximately eighty. Hence, all new grants of mining leases were made under the Mines and Minerals (Regulation and Development) Act, 1957 and the Mineral Concession Rules, 1960. With that Act, the government acquired full ownership rights over the mines.

But the mine owners´ lobby, although they were alone because they had lost the Portuguese influence, was already powerful in Goa. Therefore, in the same year, they promptly challenged the *vires* of the Act in the Bombay High Court, Panjim bench, and obtained a stay which enabled them to carry on their mining operations. America, Japan and other countries supported them due to their own interests in keeping going the iron ore exportations of the small Indian state. However, the mine owners were directed to go through the process required by law if their mining leases required renewal. (Alvares, 2002)

2. Town planning and land use

2.1. A brief introduction to the Goa's town planning background

After the independence from the Portuguese, the Goans pretended to design their Goa's future. Thus, it was created the Town and Country Planning Department (TCPD) in December 1964. Its main purpose was to elaborate the Regional Plan of Goa (RPG) in order to develop rapidly around the territory, from the tourist coastal until the enormous mine leases inside the Western Ghats. After a short time, in 1974, the Goa Assembly approved the Goa, Daman and Diu Town and Country Planning Act (Alvares, 2002).

The Chief Town Planner was required by the new Act to prepare and write the RPG. In that document there were drawn areas for different human uses, as agriculture, forestry, industry, urban and rural settlements, etc. It also defined some protected areas for recreation, the preservation of the environment (like the Wild Life Sanctuaries or WLS) and some other places with an important historical value (Alvares, 2002). The Planning Act did not allow any changes in the RPG until it had passed, at least, ten years. Even though the RPG was created with the aim of guiding the growth of the new Goa, the economic interests of politicians of that time were really the exploitation of coast. Thus, the planning became a great tool for the politicians. Especially those ones who were in charge of changing the Plan (the Chief Minister, members of the Town and Planning Board and the Town and Planning Department), earned a lot of money through the conversions of the land uses for the private economic interests. The spirit of the RPG was lost because the economic profits of the new business determined the criteria to decide if some areas were able to bear the use designed for dealing between private sector and government. Until 1986, the Plan was not notified and the government recognised that they had changed the plan more than one thousand times.

Therefore, in 1988, the government was forced to submit a revision of the RGP which had to be valid until 2001. When it really started, almost ten years later, the administration decided to hire a private consultant from Delhi (Consulting Engineering Services) in order to elaborate the new Plan. However, the mining supporters sectors were still pressing to control the definition of the land uses for their own benefit.

By the 1997-1998 the government started to prepare the Regional Plan for 2011. In 2005 they introduced an urgent ordinance (number 3 of 2005) to improve the land owners' influence on the decision of the planning allowing them so they would be able to apply for amendments in any kind of area (even in those which were not in the plan). Furthermore, it also illegally appropriated the powers of the planning authorities and vested in the state government. That new ordinance brought on the "land market".

That was the reason why the next year it was found that the government had acquired some lands with the alibi of urgency belonging to the provision of the Land Acquisition Act of 1984, so the citizens were not allowed to protest against that procedure. Even more, the general public only had 15 days to review all the changes. During the same year the second regional plan (RPG'11) was notified although they could not implement it because of the protests around the state referring to the state total control over the Goa's territorial planning. When the last Plan came to an end, in 2011, the last Regional Plan was notified.

2.2. The Eco development strategies for Goa

2.2.1. Eco development Plan for Goa (1982) Planning Commission, New Delhi

That plan was designed concerning development of the Western Ghats' hill areas. The Task Force divided the analysis tasks into five subgroups whose respective reports would make up the Plan.

The first subgroup studied the land resources and land use planning, including the physical status of the state's territory, the criteria for land uses and the agricultural planning.

The second one referred to the water conservation. It was orientated towards the centralisation of the water supply management, with the dams as the main alternative, instead of the water harvesting and other conservationist measures which were ignored.

The forests were described in the third subgroup, analysing their management in Goa, the conservation of the natural parks, Wild Life Sanctuaries (WLS) and the biosphere reserves. There was a section which dealt with the mining effects on those ecosystems. This subgroup had identified some major problems: the development along the roads, rivers and beaches; the congestion in cities; the deforestation and the cutting of the hill slopes and the uncritically building construction in town which affected the historical and cultural patrimony.

The last subgroup focused on iron mining impacts, particularly on the agriculture, the forests ecosystems and also on the pollution of the main water streams, including the depletion of the water table. That report finally suggested the creation of the Ecological Mining Board in order to restore the environment's quality of Goa although it would never be really set up.

The Coastal Area Planning included in that plan had to deal mainly with the problems of marine fisheries, the current *khazans*, mangroves and flood problems during the monsoon which caused several problems of erosion to the coastline.

The final chapter talked about the administrative methodology to implement the recommendations of Task Force. It also recommended the foundation of the Institute of Environmental Education and Management.

That plan was made thanks to the interaction between the Goa and Central government and the scientist’s institutions. The NGO’s no participation during its elaboration made that plan not really known by the general population.

2.2.2. Regional Plan for Goa 2001. Town and Country Planning Department, Government of Goa (1988)

Another important plan for the beginning of the Eco development was the RPG01, whose elaboration process has been explained in the previous chapter. The town and country planning should include different perspectives, according to the scope of the project: from the micro-scale until the state perspective. Therefore, that plan was elaborated to solve the conflicts about the distribution of land uses. One of the most important issues was the unbalanced growth between the coast and the rural area development. The RPG01's strategy had these basic values. The coastal talukas had to consolidate its economy, meanwhile, in the midland and Western Ghats, the need of conserving the land was more important. For that reason the population should also be well distributed like the plan proposed. It also introduced the role of the mining sector as a declining business because of the supposed limited ore resources and the unpredictable market versus the upcoming tertiary sector, concretely the coastal tourism, which had promoted a high source of employment.

Those strategies were based on demographic studies that helped to design also one of the most important state projects: The Konkani Railway, connecting Mumbai and Kerala going through Goa. There were many industrial and business interests in setting up the Railway inside the Goan territory. However, it is said that it finally destroyed the aim of the Plan because it disturbed the other focus of the different strategies defined by the Plan.

There was also another ecological issue that created controversy along the ecologist sector: the elimination of every "wastelands". In fact, scientific researchers showed that those lands were more like wetlands because they provided the area with the reservoirs of the rainfall water coming from monsoons. Besides, they also had become a biodiversity hotspot that must be preserved.

Nevertheless, after the notification of the RPG'01 the politicians helped by the Town and Country Department officers, rapidly forth and amendment in order to change the Plan to their own will, dissolving the ecologist spirit of the original Plan.

2.2.3. Regional Plan for Goa 2011. Town and Country Planning Department, Government of Goa (1999)

As it is said in the first paragraph of this chapter, the RPG'11 was elaborated by the Consulting Engineering Service, which was from New Delhi. It is considered one of the main reasons why that plan did not go deeper in the Eco development of Goa. In fact, most of the database that they used in the report was also available on the internet from other public sources, like the Statistics Department. For example, the conservation discussion in the RPG'11 was entirely referred to the Conservation Committee's report. Even the discussion of the iron mining issue is based on The Energy and Resource Institute's report about mining and its impacts of 1999.

Therefore that Plan did not introduce any innovation or new strategy to the Eco development of the Konkani region.

2.3. The current distribution of the mining leases: Regional Plan for Goa 2021

In 2011 the government of Goa notified the Regional Plan for Goa 2021 which defined the policy strategies of development and conservation in a twenty years perspective.

In the second release of that Plan, there was an exhaustive analysis of the iron mining situation in Goa. First of all, it described the origins of that business and its management. Then, the impacts of iron mining over the environment and the society of Goa were numbered below. It also explained how the mining leases were mapped. The authors clarified that they had also identified on the maps the dumps, pits and mines located beyond the mining leases boundaries. The State Level Committee members wrote down some recommendations to preserve the health of the environment of Goa, which is directly directed to the Goan people well-being.

Apart from those recommendations in the second release they added twenty-one appendices which contained: the list of the active and valid mining leases; the mapping about the land uses (including some specific maps about the mining issue); the surface utilisation plan for each taluka; the schedule of tribe's population in Goa and the railway mining link. Concretely, the entire database about the mining leases was classified per talukas and mining companies, always including the T.C. number which identified each mine lease.

TABLE 6.1 : ACTIVE AND EXISTING IRON MINING LEASES IN GOA (2010)

TALUKAS	Active mining leases	Existing mining leases	% Active	% Existing
Bardez	1	4	0,9	1,2
Bicholim	30	59	25,6	17,6
Canacona	0	1	0,0	0,3
Pernem	0	2	0,0	0,6
Ponda	0	3	0,0	0,9
Quepem	8	27	6,8	8,0
Sanguem	60	205	51,3	61,0
Sattari	18	35	15,4	10,4
TOTAL	**117**	**336**	100,0	100,0

Source: RPG21 (Appendix IV and V)

In Goa it is clearly defined where the hotspots of the iron mining activity are. Most of active mine leases are placed in Sanguem taluka (51.3%of the active ones) followed by the talukas of Bicholim, which has one quarter of the active mining leases (25.6%) and Sattari with a 15.4%. Hence, the mining industry is mostly located in the territory within those talukas, which belonged (most of them) to the Western Ghats' boundaries forested area, creating a longitudinal belt crossing Goa from North to South. The rate of active leases according to the total amount of existing mines is almost 50%. It is also very important because although a half of the mining land is no producing any benefit, it cannot be suitable for another land use, like forest exploitation or even harvesting for the rural people.

TABLE 6.2: MINING IN EXISTING LAND USES

TALUKA	Area of lease (km^2)	Settlement (km^2)	Water body (km^2)	Forest (km^2)	Private forest (km^2)	Paddy (km^2)	Industry (km^2)	Orchard (km^2)	TOTAL
Sanguem	**46,83**	**1526,01**	**3606,75**	**17,77**	**1287,60**	**66235,54**	**1640,77**	**25,05**	**2813,61**
Bicholim	**20,79**	1549,42	4467,89	4084,74	0,00	4949,61	610,30	14,16	5634,16
Quepem	**12,20**	4763281355,00	4232,96	1667446,78	0.00	5912,41	51,20	8993465,59	0,05
Sattari	**12,69**	1022,14	4937,80	1,65	0,00	3449,26	0,00	9180,48	10204,27

Source: RPG21, Appendix VII

The table 6.2. is also really interesting because it shows how the land uses are divided by talukas and where the iron mining activity makes more pressure. Looking at that figure the conclusion is clear: the land uses that have more area under the mining leases are the forest and the orchard. In Sanguem, for example, the forest involves more than a quarter of the mining area and the orchard is almost a half of the total mining lease surface of the entire taluka. In the other talukas mentioned in the table the trend is similar to the Sanguem's one but are not as clearly defined as the first one.

TABLE 6.3: MINING ACTIVITY OUTSIDE MINING LEASES AREAS

TALUKA	Area under active mining (km2)	Mining area /mining activity outside active mining lease (km2)	% of area outside mining lease
Bicholim	2,54	0,04	1,57
Dharbandora	23,43	3,3	14,08
Sanguem	23,82	4,63	19,44
Sattari	12,69	2,28	17,97
Quepem	11,87	0	0,00
Total area	74,36	10,25	13,78

Source: RPG21 (Google Images)

The percentages of mining area outside the lease are really remarkable. In fact, Sanguem is the taluka where more mining activity is not within the leases' boundaries (almost 20%). Moreover, it is said in the RPG'21, the results of the last figure (regarding to the source) have been taken by using the Google satellite images which were not up to date. Hence, four years later, it is pretty sure that nowadays those rates have increased. In addition, another noticeable aspect of those Annexes is that only on the Figure 2.3.3. The Dharbandora taluka is mentioned without any explanation from the reporters of RPG'21.

2.4. Requesting procedure for a lease

In order to understand the current situation of the iron mining in Goa it is necessary to know which are the conditions and procedures to apply for a mining lease in Goa.

After the independence of Goa, those ancient “concessions” were renamed as “leases”. There were then regulated under the Indian Mines and Minerals (Development and Regulation) Act of 1957 and the Mineral Concession Rules of 1960 (RG21) in order to control the proprietary interests of that mines (Alvares, 2002). The Mineral Concession Rules of 1960 contains the conditions that every mining lease has to comply.

First of all, it says that the discoveries inside the lease must be reported to the State government if that type of mineral was not reported before. That point is not so important because most of the mines in Goa have had the same kind of mineral since its origins. The mine owner should pay the dead rent or the royalty for the mineral which has the highest tax amount if there were more minerals in the same lease. They also have to pay to the old owner of that land as a compensatory arrangement.

Referring to the town planning, no mining lease is allowed to do any operation in a place closer than fifty metres from any kind of public work or building except if it is allowed by the State government. The mine owners are obliged to report any kind of operation related to the exploitation, including the subsoil and strata analysis.

That rule has also considered a very important aspect of mining: the employment. It recommends favouring the people who have been evicted from their land to help in the mining operations, guarantying the minimum wage approved by the Central or State government.

In a small article, for the first time, the mine owner was obliged to plant in the same lease, or even in another place of Goa, at least twice the trees that had been deforested by his own mining activity. Even more, it says that they should take care about those plantations (its flora and fauna) until the lease period comes to an end, when the State or Central government (or another authority nominated by them) will take care of that area. In spite of that innovation in the mining law, hardly any mine owner has ever fulfilled this request because the normal procedure is to leave the mining exploitation without doing any recovering measure on land.

In order to control that the mine owners fulfil every condition of the Mineral Concession Rules, an authorised officer from the State or Central government is allowed to inspect the activity which is done inside the mine lease. Nevertheless, the current reality is that those officers are usually bribed by the mine company to not to reveal “irregularities” on management.

The government, in relation to what is said in that Rule, has always the pre-emption of the extracted minerals inside the lease. Hence, the State government is always able to buy the mineral according to the market prices.

The Goan reality is quite different; it is often more complex like it has been explained before. Interviewing the local people someone can realise that the distribution of the mines is not as legitimate as the administration pretends to show to the population.

Rajendra Kakodkar is a management consultant who worked for Fomento mine company time ago, and he has become a sceptical observer about the iron mining issue in Goa (in fact he has published some articles in the Goan newspaper O'Heraldo). During the interview (14^{th} of November 2012), he said that current companies which want to obtain a lease have never needed to pay anything because the government cannot allow any other land to be converted into a mining exploitation. The leases used to be traded between mine owners with no governmental supervision, thanks to the implementation of the auction mechanism. Thus the government has totally lost the control over the mining lease trading.

On the other side, Joseph Cuelho, the responsible of the South Goa district of mining company SESA Goa, has another point of view of the issue. First of all, he affirmed in the interview (dated on 8^{th} of November 20129) that the mining can belong to somebody for 99 years. At the beginning of company's spread, they used to buy the mine land to the village people. J. Cuelho was convinced that the amount of money that SESA Goa, as the rest of mine owners, given to them was enough to compensate the loss of their crops or their forest exploitations. Even more, SESA Goa conducted local people several compensatory measures in order to have them in favour. For example, they offered employment inside the mine plant. Furthermore, they gave the men the chance to work as transporters, paying the truck for them. SESA Goa also built in those towns a free medical clinic with the main purpose of treating the healthy consequence of living nearby the mine leases.

3. Environmental legislation and policies related to the iron mining

Although in the developed countries the environmental policies and legislation have several years of history, in India it took them more time to create a solid framework about the protection of the environment. The improvement of Indian's economy during the last period of the twentieth century could be the main reason why the Central government of that time started to regulate the environmental resources and the economic activities' impacts. Notwithstanding that lack of awareness during the first decades of India's independence, some important policies and regulations were implemented in order to guarantee the conservation of the rich diversity of ecosystems of the country.

3.1. Environmental and mining policy

Policy is generally defined as the guideline that the administration adopts in order to develop its country. In India, the most relevant policies that have been written for preserving the environment are the following ones:

3.1.1. National Forest Policy, 1988

It was focused on protecting the forestal areas against the increasing of the fuel-wood demand and the expansion of other uses like industry and mining. Thus, some of the main objectives of that policy were:

- guarantee the stabilization of the ecological balance
- the preservation of the biodiversity of flora and fauna
- the soil erosion and the hydrological reserves
- the sand-dunes protection along the rivers, lakes and beaches
- encouraging the governments to improve the forest cover
- considering the village people and the tribal's necessities referring to the forest resources.
- an efficient utilization of the forest and improve the research and implementation of wood-substitutes.
- introduce the women in the ecological affairs.

Moreover, the forest needs to be considered as an ecological renewal service, instead of natural revenue exploitable in anyway. The mining industry is only mentioned in a single paragraph. That policy recommended to mine owners or "beneficiaries" (it does not talk about any obligation) to include in their exploitation projects, some compensatory measures to reduce the impact of the mining activity. It also asked them to restore the original ecosystem when the ore extraction was finished.

3.1.2. National Conservation Strategy and Policy Statement on Environment and Development, 1992

It was an ambitious policy because it included many aspects of the environment, apart from the definition of some environmental figures that could be compared to the occidental ones. Its principal aim is an equal relationship between the economic development and the environmental awareness so it pretends to readjust the economical and territorial planning of India towards an ecologist perspective.

Due to that tenet, there have been defined some instruments to fulfil its agenda. First of all, the Environmental Impact Assessment (EIA) will be necessary for all development projects, as the Environmental Clearances (EC) in order to implement the environmental legislation. Finally, the encouragement of the population to learn about the planet needs and participate in the environmental movements is one of the clues.

That policy is also worried about some demographic aspects which have always influenced on the environment equilibrium, like the population overgrowth of the Indian country and the role of women in the rural development. In fact, it is said before that the demographic growth should be controlled and the feminist movements are also considered as a very important clue for the ecological conscientious process.

Finally, there is a chapter about mining. It has been considered the need of a properly restoration management of affected areas, including sensible surrounding areas. Furthermore, that plan introduces the concept of mining by-product in order to be preserved for a potential future use.

3.1.3. Policy Statement on Abatement of Pollution, 1992

In the same year as the previous policy, it was written the guideline to control and reduce the amount of pollutants and waste which are uncontrolled discharged to the environment. One interesting point is its long term planning vision related to poor people, the most sensible social class. Moreover, two solutions for abating the pollution generation are proposed. An increase of the legislation related to the waste management and the encouragement to the governments to increase the financial incentives. Thus, the private sector became a real collaborator to the preservation of the environmental health. The social awareness is also necessary to success in that implementation, harmonizing the economic and social development with a healthy environment.

Like other strategic documents, there is a specially mention about mining sector which is forbidden for the Pollution policy in the fragile areas of India. Furthermore, mine owners should be obliged to have time bound reclamation for lease areas.

3.1.4. National Environment Policy, 2006

This report is the current environmental main guideline and is especially ambitious regarding to its proposals written for each issue. Notwithstanding the nature of that document, which is not coactive to any government, there are some new-fangled concepts and figures that should be noticed. They show a new guideline supporting the environment real value and the ancient knowledge of the rural and tribal society.
It also considers the sustainable development of the economy, which is an unbreakable right of India, must depend on the human well-being and, at the same time, on the environment. The government, as it is said, is not the single influent of the status of the ecosystems. In fact, one of the most important drivers of degradation is the huge Indian business growth and the enormous poverty that it causes. Concretely, the women and the tribal collective are directly related to the environmental impacts and their consequences.

The weakest population classes do not dispose of the natural resources of the land, so the effects of their activity are worse. In addition, due to their inappropriate mining practices, the consequences of those impacts are redirected to the life quality of the lower classes that cannot bear that unhealthy situation.

The objectives of the environmental policy are mainly focused on the preservation of the natural resources, considering the efficiency in their use and the recycling for the future generations. That is one of the innovating aspects because it analyses the environmental consequences of human acts in a long-term period which includes the mining activity around the state.

In almost every issue is described mining as an important cause of pollution, degradation and health hazards for the surrounding social and natural spheres. The mountain, the forestal areas and groundwater, for example, have been endangered by the mining exploitation because of the huge scars that open mines make on the forested surfaces on mountain slopes and the water tables of the area have just go down, hurting the village people who live nearby mining lease and above all they depend totally from the groundwater supply.

Despite those mentioned strategies, mining is a pressure for Indian ecosystems and population's welfare. Especially in Goa it was necessary to design a policy about the Major (iron) mineral due to the huge presence of that business around the Konkani territory, concretely along the Western Ghats. It is a fragile ecosystem, really important for village people who can harvest and obtain fresh water thanks to those mountains. Thus, in 2012, it was written the Draft Goa Mining Policy (Major Minerals) 2012.

3.1.5. Draft Goa Mining Policy (Major Minerals) 2012

The Draft Goa Mining Policy of 2012 was written because of the corruption of the previous government (with regard to what is said in that draft). It says the current problems caused by the management lack during the last decades made this report necessary in order to change the development trend of the mining business in Goa. It can be summarized in few lines because in any chapter it is referring to sustainable exploitation of iron ore and land recovery. The policy also refers to the social impacts of mining and the measures to implement for the purpose to solve those problems, including the unemployment and the welfare of the weakest sections of population. The main objectives that are assumed by the mining policy are the followings:

- sustainable exploitation
- geological mapping of mineral resources
- improvement of the employment
- implement control and preventive measures
- create a major minerals database
- promote the private sector participation
- guarantee the stakeholders rights

In addition the mining policy also includes some interesting information about the iron ore exploitation business. For example, it is reported that the annual export collection (assuming an export duty of 30%) is U$720million (4,000 crores), amount which is not shared with the state of Goa by the central administration. Those taxes are concretely 18$/metric tonne or in crores 1,000 INR/metric tonne.

Nevertheless, through the numerous articles, some of them are important to analyse because they show how those kinds of documents are elaborated. Notwithstanding the iron ore extraction is entirely oriented to the foreign exportation, the policy affirm that the main focus of the iron mining should be the own steel production, instead of selling the ore abroad, which has been analysed deeply in the previous chapter.

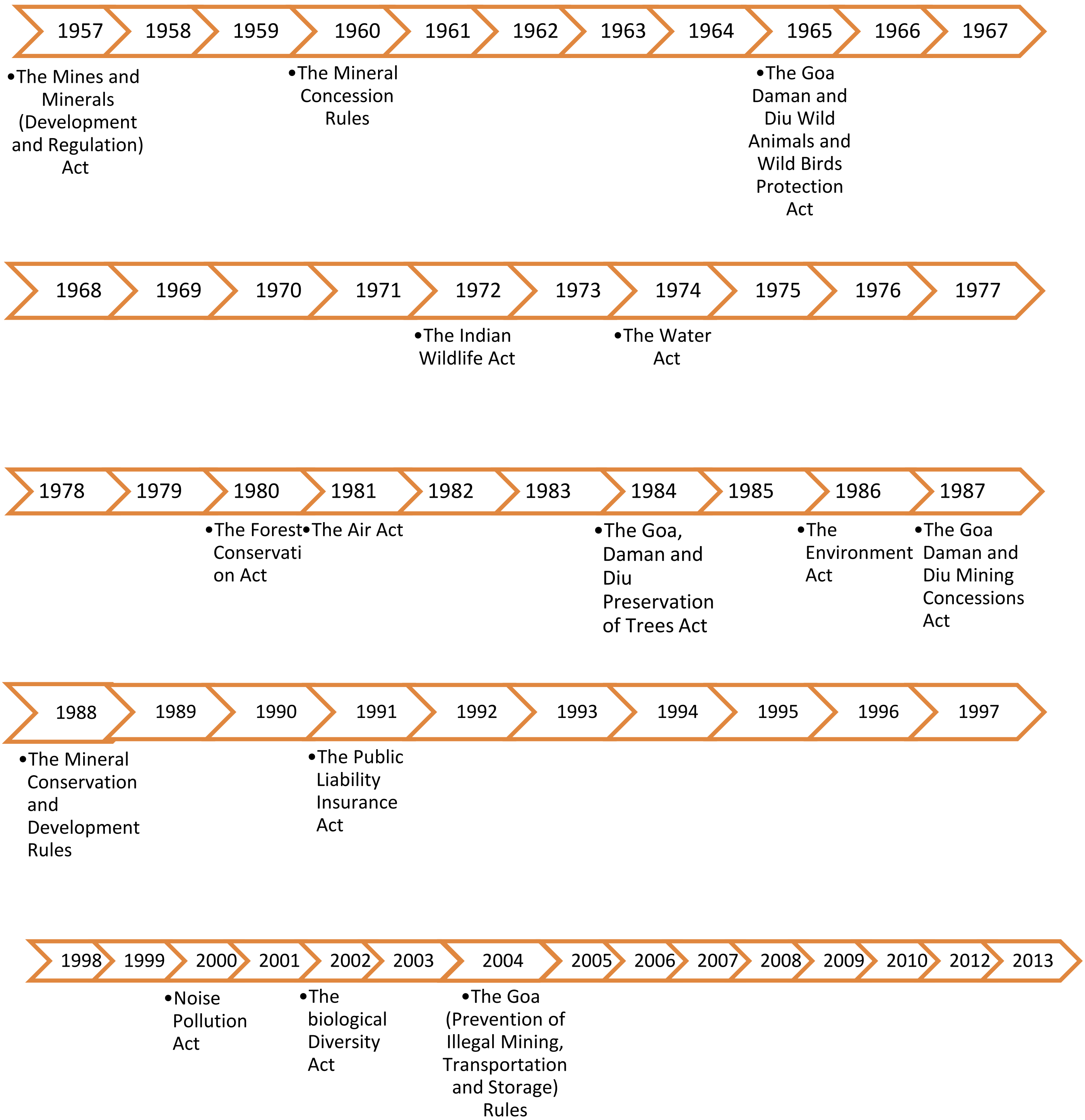
The sustainable development of the iron mining in Goa, the first point of that policy, it considers to make a proper inventory of iron reserves so a correct approach can be done for the next years. It also puts emphasis on the ecological closure plan of a mining lease in order to return the original ecosystem services that the mine land had had to the surrounding environment and people. Moreover, the benefits or "the fair share of revenues" should be invested in those ecosystem services and the improvement of the quality of life of the people who live nearby the mines, above all, for the future generations. Finally, it affirms Zero Tolerance to illegal mining.

The policy dedicates some chapters about the dumps and its impacts on the iron mining economy and the surrounding area. Because of the drop of the iron ore prices the authors of the Draft suggest that it could be better to export as soon as possible. At the same time, it has been estimated that the total amount of ore lying in dumps is 700Mt (2012). The majority of those dumps are located outside the forested areas, although they recognise that some are inside the Sanctuary areas. Hence, no more fresh mining should be authorised. In addition, they propose the same new cap of 25Mt/year, like Bellary did before.

The mining policy considers the most vulnerable classes of the Goan society in the stakeholder’s scheme of mining. Tribal people, women, children and the poorest people are those which form that sensitive social class. The Draft pretends to invest the 3% of the annual benefits of iron mining in social development programmes which should guarantee the welfare of the people who are more affected by the mining adverse impacts.

The environmental legislation of The Indian Union has been summarised in a historical scheme, including some of the Goan legislation related to the environment and mining issues in order to see how the Konkani state has adapted to the central legislation.

3.2. The environmental and mining legislation in the Indian Goa



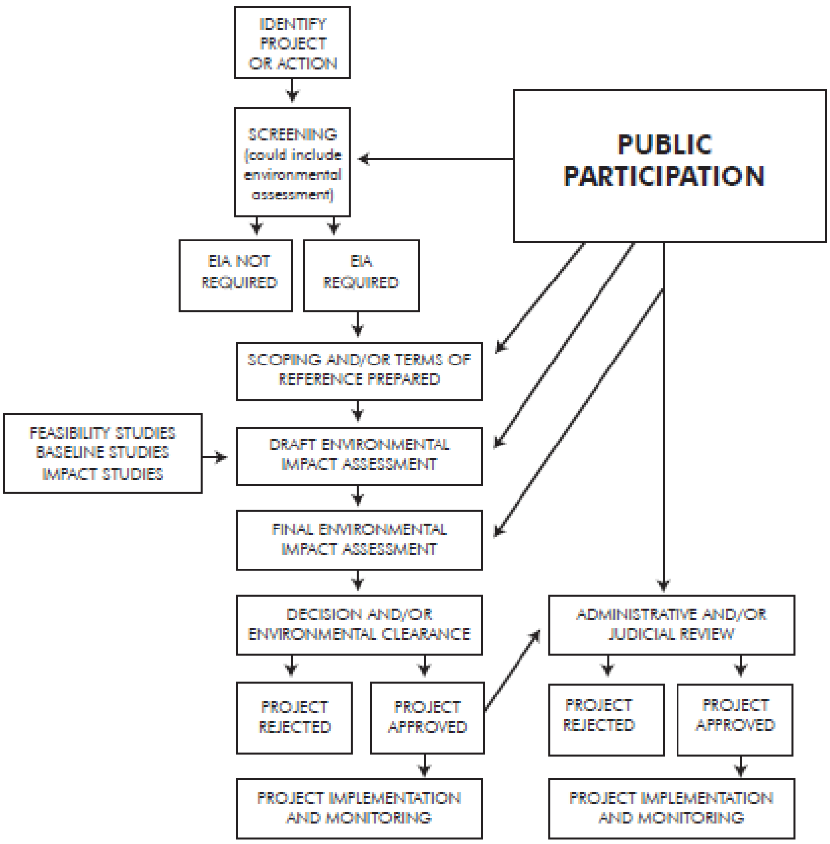
4. Environmental management of iron mining

Mining activity has been changing since once the ore was being removed with the help of pickaxes. In fact, during the recent decades, especially after the Second World War, mining has witnessed an incredible rapid growth of human ability to alter the environment. Therefore, many well planned actions were initiated in order to ensure that such developing sector did not inflict any damage on environment, or they excessively disrupt people's well-being and health. In the developed countries those measures were implemented very seriously. Then, thanks to Mrs. Ghandi's intervention in the Stockholm Conference on Human Environment in 1972, in India, she introduced the environmental management perspective to development projects. (Gadgil and M. Dongre, 2012)

In fact, the function of an effective mining management is to prevent (or minimize) the impact of ore extraction (B. Dhar, 2000). For this purpose, the tools developed include the specific conditions reported by Environmental Impact Assessment (EIA) when Environmental Clearances (EC) is given. Moreover, Public Hearings (PH) seeks public inputs in the decision of making process in order to incorporate mitigated measure elements into Environmental Management Plans (EMP).

4.1. Stages of the EIA process

FIGURE 6.1: SCHEME OF THE EIA PROCESS



Source: Environmental Law Alliance Worldwide (ELAW), 2010

The Environmental Impact Assessment (EIA) is defined by the Guidebook for Evaluating Mining Projects EIAs as "an interdisciplinary and multistep procedure to ensure that environmental considerations are included in decisions regarding projects that may impact the environment" (ELAW, 2010). It helps to assess the quantitative values of environmental parameters and impacts of the intending activity. Also it identifies preventive, mitigation and reparatory measures in order to compensate the identified negative effects. However one of the most important information provided by this assessment is the design of feasible alternatives for each project. (MoEF, 2010)

Thereby, EIA documents inform to decision-makers and public about the environmental and social effects of the implementation of the proposed project. It gives them feasible measures to reduce those impacts. Despite ensuring informed criteria, decision-maker is able to choose the worst environmental alternative, provided that its consequences are reported on the EIA.

But it is not as simply as writing an environmental report about the mining consequences on that area. All new projects scheduled in the EIA notification of 2006 are required to obtain an Environmental Clearance (EC) before starting their activity. Furthermore, for certain kind of developmental projects, EC has been made mandatory by the Ministry of Environment and Forests through its Notification issued on 1994. Few steps need to be followed in order to obtain the EC from the administration as it shows briefly the Figure 6.1.

First of all, there is the **Screening** process. It determines which project needs to fulfil an EIA study and which does not. Every activity is classified in two groups (A and B) depending on:

- Project size and location
- Spatial extent of potential impacts
- Potential impacts on human health
- Natural and man resources

Thus, the criterion for the mining activity is based on the mine lease area, although it also considers the proximity to sensitive areas as an exceptional case.

TABLE 6.4: MINING CATEGORIES

Project Activity	A Category	B Category	General Condition
Mining of Minerals	= 50 ha of mining lease area in respect of non-coal mine lease >150 ha of mining lease area in respect of coal mine lease Asbestos mining irrespective of mining area	<50 ha = 5 ha of mining lease area in respect of non-coal mine lease = 150 ha = 5 ha of mining lease area in respect of coal mine lease	Any project or activity specified in category B will be treated as category A, if located in whole or in part within 10 km from the boundary of: (i) Protected areas notified under the Wildlife (Protection) Act, 1972; (ii) Critically polluted areas as identified by the Central Pollution Control Board from time to time; (iii) Eco-sensitive areas as notified under section 3 of the Environment (Protection) Act, 1986, such as,

Source: MoEF, 2010

Thereby, if the project/activity is under category A, it is going to be referred to the Ministry of Environment and Forest (MoEF) at the Central Level but the B categorised project has to be referred to the State Environmental Impact Assessment Authority (SEIAA) from the state administration.

In case an EIA study is needed, the next step is the **Scoping** process. It identifies the environmental issues which need to be included in an EIA. During this step the general public and the NGOs have the chance to participate in the creation of a list of issues that the EIA should consider in its study. Also they help to reveal some problems which can be mitigated or may be cause the cancelation of the project.

When the scoping is finished and every important issue of the project has been noticed, it is the moment to write an **EIA Draft**. Generally, an EIA study always includes some terms of reference as a guideline with the considerations of scoping. Hence, the basic frame of the Environmental Impact Assessment has the following terms (ELAW, 2010):

- a description of the project
- a list of the agencies or ministries responsible for overseeing the EIA process and making decisions
- the geographic area to be studied (also called the 'impact zone')
- EIA requirements in applicable laws or regulations
- impacts and issues to be studied
- mitigation and/or monitoring systems to be designed
- provisions for public involvement
- key stakeholders
- timeframe for completing the EIA process
- expected work product and deliverables
- budget for the EIA

In this step, an evaluation of technical specialists is required so they can evaluate the impacts caused by the proposed project and design the mitigation measures.

Before it is prepared the final EIA document there must be a **Public hearing**. In fact, although in almost every step it is done, the final one is often the most known because it is during the final EIA elaboration when people can easily share opinions and discuss about the pointed out issues of EIA draft. The administration officially gives 30 days to the interested people (most of them usually affected by the project) in order to apply for a correction or maybe for a change in some of the discussed points.

Finally, the corrected EIA study is sent to the corresponding authority in order to determine whether the project is rejected or approved. In the first case, the responsible must review the report, helped by another public hearing. But, at the moment that an EIA fulfils every requirement, the EC is given to the owner. After that, the mining project can be implemented.

Although the EC allows the mine owner to operate over his lease, a monitoring procedure is necessary because it ensures that measures are properly implemented and the effectiveness of those actions.

Unfortunately, Goan mining owners consider those environmental measures only as token activities without serious application. They do not appreciate anything else apart from financial benefits of their companies. In fact, the mining business, as it has been said before, has a strong influence in Goa, even in the environmental management. If the state government is interested in helping a mining company to start its activity in a concrete area, they will reduce as much as possible the total days of public hearing so the people will not have enough time to check if there is any mistake or irregularity in the EIA study.

Moreover, Ramesh Gauns, a school teacher and a popular environmental activist, told the researchers that SESA Goa has constructed Indus temples to the village people in Bicholim (North Goa) so they have to support the mining projects that were submitted by them. This is only one example of the capacity of that powerful sector to put in favour the population to their own interests.

However, in April 2012, after the submit of Shah Commission report about the illegal mining, which is going to be explained in the next paragraph, the government of Goa asked the Centre for Environment Education (CEE), headed by Mr. Sujeetkumar M. Dongre, to check the EIA, EC, PH and EMP o 105 mines. That could bring the weaknesses of the current system. Thus, economic development can become sustainable and share the benefits to society.

5. The current political situation of iron mining in Goa

5.1. The mining stakeholder's analysis

In the following paragraph it is going to be described the main stakeholder´s involvement in the mining exploitation in the state of Goa so it can be understood the political context of that issue.

First of all, it has been used a Venn diagram in order to classify every relevant stakeholder's role in the mining issue. Thus, three parameters have been considered in the following diagram:

- **Power**: capacity to change the current scene.
- **Influence**: capability to persuade the decision-maker.
- **Vulnerability**: inability to bear a new harmful situation due to previous stakeholders' social and environmental context.

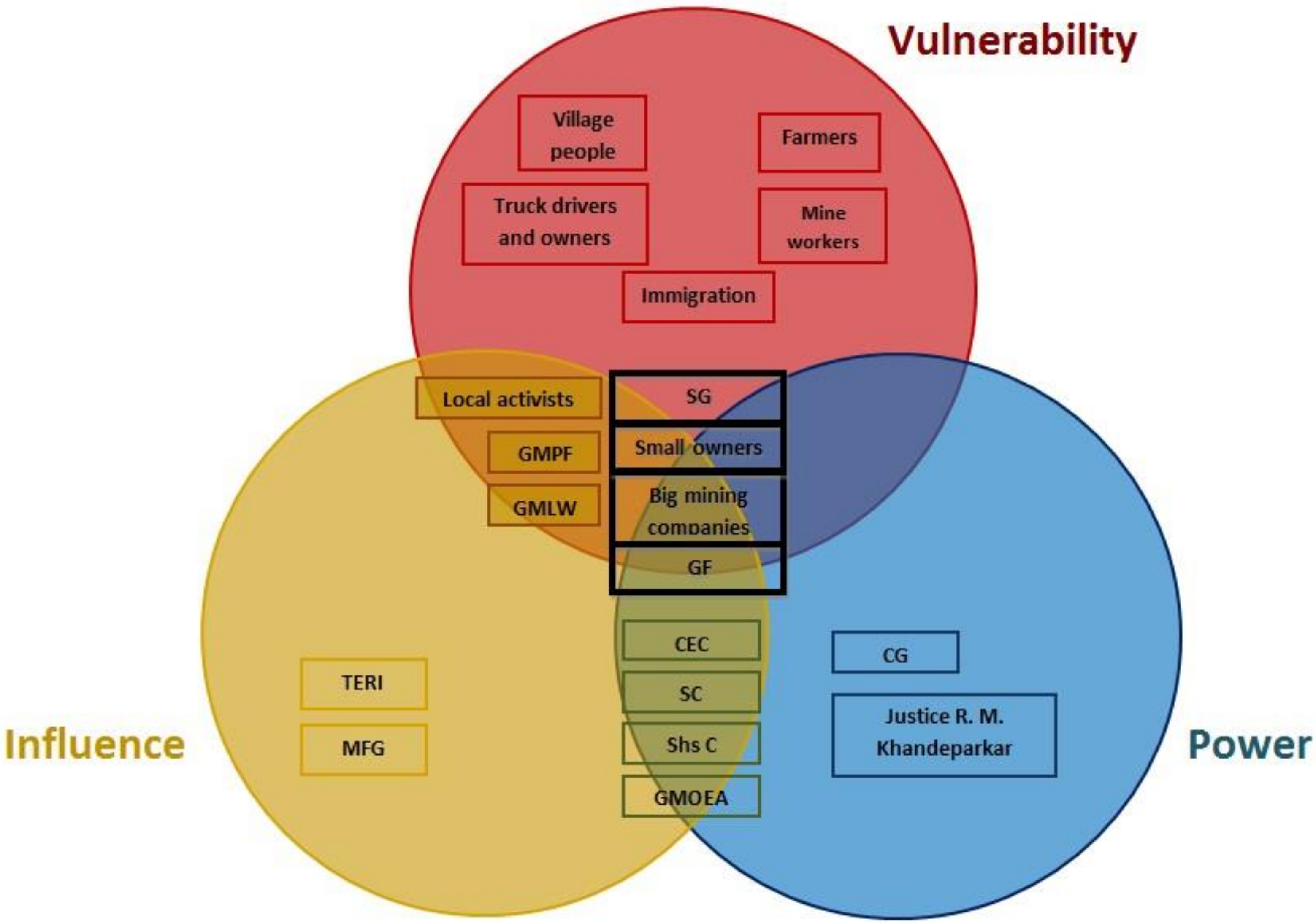
One of the main conclusions achievable from Figure 6.1 is the fact that the most important stakeholders of Goan iron mining are located in the intersection between the three parameters. Indeed, those roles who have an official power to make coercive decision, their opinion is considered by the rest of the public and, at the same time, are also affected by the negative effects of the problem, they can be considered really involved in the mining issue.

It is clear why the mining business (including big companies and small owners) is the protagonist. That business is entirely responsible of environmental and social impacts on Goa's land, but, at the same time, they are paying the direct consequences of the ban on iron mining.

Another example of an important role is the NGO Goa Foundation (GF), headed by Dr. Claude Alvares. Although its members are environmental activists affected by the harmful impacts of iron mining extraction and trading, they have been so influent to both State Government (SG) and Supreme Court (SC) thanks to the claiming for the illegalities done by the business sector. The iron mining bans declared by the SG and thereafter by the SC shows the really power of that NGO.

Finally the State government plays a curious role in the current moment: it has to deal between the previous stakeholders so an engaged final decision is achieved. It needs to complain about the powerful mining lobby but, if it wants to continue on the state administration for the next legislature, it should pay more attention to the social protests against mining.

FIGURE 6.2: STAKEHOLDER'S ANALYSIS



Source: Own elaboration

TABLA 6.5: STAKEHOLDER'S DETAILED STUDY: PUBLIC ADMINISTRATION, CIVIL SOCIETY AND MINING INTERESTS

Public Administration				
Name (acronym)	**Role/focus**	**Member organization**	**Target of acting**	**Actions**
Shah Commission (ShC)	Proving that the government is concerned about the iron mining irregularities Justification and encouragement of the iron mining business future in Goa First official supervisor of the iron mining business	SG, NGOs and scientific workgroups	Mining owners	Checking the illegalities Writing the iron mining report Classifying the mining leases
Central Empowered Committee (CEC)	Superintend the Shah Commission working Analyse the iron mining management irregularities	SC	ShC Mining owners	CEC report
Supreme Court (SC)	Stop the iron mining exploitation Authorize the CEC actuation Decisive in the future of the iron mining business	Judicial power	SG Mining owners	Judging the current situation of mining Considering the ShC and CEC report
State government (SG)	Dealer between the mining lobby and the population Implicit supporter of the mining business	BJP party Manohar Parrikar, Chief Minister	Local people Mining owners	Assignment to the Shah Commission the mission of checking the irregularities in the mining sector Helping the unemployed people Holding the social protests for and against the mining ban Asking to the SC to restart the mining activity
Central government (CG)	Concerned about all the problems of mining sector around the nation Often contrary to the Goan SG	National Congress Party (NCP) Manmohan Singh, Chief Minister	SG SC ShC	Pressuring the Goan government to react in front of the delicate situation of the state
R. M. Khanderkapar Committee	Alternative tool for the government to fight against illegal mining	SG	Mining owners	Checking the illegalities Preparing a road map for Goan mining industry

Source: Own elaboration

Civil Society				
Name (acronym)	**Role/focus**	**Member organization**	**Target of acting**	**Actions**
The Energy and Resources Institute (TERI)	Analyse the iron mining influence on the Goan society and environment	Scientific independent researchers	The Goan society and environment	Investigation and publication of reports
Immigrants	New citizens of the villages near by the mine leases	People from the neighbouring states (Karnataka, Maharashtra, etc.)	-	Working on the mines Driving the mining trucks
Goa Foundation (GF)	Raise awareness about the iron mining hazard effects on the Goan environment and society Pressuring the government and the judicial power A total competent adversary against the iron mining business	Goan environmentalists	SG and CG SC Mining owners	Paralyzing the iron mi mining activity Analysing the incongruence of the ShC and CEC reports Arguing with the government in order to stop definitely the mining
Local activists	Raise awareness about the iron mining hazard effects on the Goan environment and society Environmentalist leaders for the villagers	Local people with a wide knowledge about the Goan environmental problems	The state government and the mine business	Hindering the mining activity Advising the local people about the effects of iron mining Encouraging the people to protest against the mining lobby
Village people	Affected by the iron mining activity hazard effects and aware about Directly linked to the health of the surrounding environment Divided by different attitudes about iron mining business	People who live in the villages near by the mine leases Families sustained by the iron mining Families with employment affected by iron mining business	Mine owners SG	Protest for and against the mining ban Conflicts between the mine workers of the village and the other inhabitants
Farmers	Passive affected by the mining activity	Local rural people totally dependent on the fields	-	Fighting against the adverse conditions of harvesting due to mining

Source: Own elaboration

Mining interests				
Name (acronym)	**Role/focus**	**Member organization**	**Target of acting**	**Actions**
Mineral Foundation of Goa (MFG)	Supporters of the iron mining industry The ecologist banner of the mine companies	The Goan bigger mine owners	Mine owners Local people	investing in social and environmental projects to the people most affected by mining
Big mining companies	Most interested stakeholder in mining business reactivation Unaware of social and ecological problems of mining lawless operators during the last decades	The owners with more mine leases in Goa	SG Local people	Waiting for the Supreme Court decision Helping the unemployed people Costing an entirely paralysed business
Small owners	Most interested stakeholder in mining business reactivation Unaware of social and ecological problems of mining Lawless operators during the last decades No as powerful as the big mining companies	Local people whom in the past achieved a mine lease	SG Local people	Waiting for the Supreme Court decision Costing an entirely paralysed business

Mine workers	Workers dependent on mining business future Employees submissive to the mine owner will Affected by the ban on iron mining	Local and immigrant people, generally without studies	-	Living from the partial unemployment benefit received from the private companies Looking for alternative jobs Going back to fields
Truck drivers and owners	Workers dependent on mining business future Supporting the mining business Affected by the ban on iron mining	Local people but generally form Karnataka	-	Looking for alternative jobs Living without any unemployment benefit
Goa Mining People's Front (GMPF)	Regroup the affected people by the ban on iron mining Protest against the delay of the government to reactivate the mining business Supporting the mining business	People affected by the ban on iron mining	SG	Encouraging the people to protests against the government
Goa Mining Labour Welfare Union (GMLWU)	Defender of mining workers labour rights	Mining workers	SG SC CG	Supporting the restart of mining activity
Goa Mining Ore Exporters' Association (GMOEA)	Supporting the mining export trade Protect the interests of mining companies	Mine companies	SG CG	Supporting the restart of mining activity Publishing reports supporting mine business

Source: Own elaboration

5.2. The 10 keys of the iron mining ban

Why is the iron mining still banned in the state of Goa? Since the 10th of September of 2012 the Supreme Court has been investigating the illegalities on the mining business applied by the Goa Foundation without any definitive conclusion. In the following chapter there are ten clues described which explain the strange current situation.

I. The leases distribution: the beginning of the mining lobby (1947)

During the last period of the Portuguese regime, the mining leases were granted, as it has been commented in this chapter, to some few influent families which were Portuguese supporters, like the Chowgule's, Dempos, etc. After a while, those families became rapidly very rich and therefore, really powerful, not only in the economical circles, even in the political scheme. That oligopoly has always pressured each government to protect the mining activity against any opposition. Even more, the mining minister is said to be bribed by them in order to overlook the "irregularities" of the mining leases and the hazard uncontrolled impacts to the environment and the villagers. Regarding to the interviewed people and the local and central media, the debt of the mining owners to the government is around 35,000 INR crore.

II. Awakening of the environmental awareness (80's)

Until 1981, nobody had objected to the mining model in Goa. Nevertheless, the accident in the fertiliser plant's pollution over the Zuari River the public protests started to emerge. The then Prime Minister Indira Ghandi, in 1982, promoted through the Planning Commission on Eco-development of Goa the Task Force with detailed recommendations for "ecological mining". The first Regional Plan for Goa, published in 1986, included some of these suggestions.

In the ninety's, The Energy and Resources Institute (TERI) began to explore the environmental dimensions of the mining context and its impacts to the ecological equilibrium and human wellbeing. Thus, in 1996-1997, TERI wrote a report funded by the government titled "the Area Wide Environmental Quality Management (AEQM) plan for the mining belt of Goa". This study analysed the harmful effects of the large scale iron mining evidenced on land, air and water. It also calculated some cost-based measures (between Rs. 5 per tonne and Rs. 14 per tonne) for rehabilitation and repair. Neither mining industry nor Goa government considered those advices. (Goa Today, 2012)

III. China needs iron (2008, approximately)

During the first decade of the 21th century the iron mining has become totally out of control. One of the main reasons of the huge benefits of exporting the iron ore was that China needed this valuable mineral to produce its own steel for its accelerated development in order to maintain its GDP increase of 8-10%. In fact, regarding to Dr. N. Kamat of Goa Today's report of November 2012, China hiked the prices of iron ore importations between 2004 and 2005. While in 2004 the import price was $16.39 (per Dry Metric Tonne), the following year it was almost doubled ($28.11) until the amazingly peak of $187.18 in February 2011. In addition, the Goan mining investors were also interested in selling to China because of its own fiscal benefits of having their bank accounts in a foreign country as China or even the European fiscal paradises.

Thereby, the mining lobby was the authentic manager of the business, above the state government ministries, which were also manipulated by the most powerful mining companies. The total amount extracted from the pits, the dump accumulation and the exported tonnes of iron were by far more than the rates imposed by the state government. Any social and environmental measures against the impacts of the mining extraction had been done. Moreover, when the mine lease was abandoned nearly nobody recovered it.

It all started around 2003-04 with China going on a construction spree in the run up to the 2008 Olympics. China is the principal importer of Indian iron ore and procures 91 per cent of what India exports, according to the Indian Bureau of Mines (Down to Earth, 2013).

IV. The setup of the Shah Commission (22th of November, 2010)

The Central government created the Justice M. B. Shah Commission of Inquiry for Illegal Mining of Iron Ore and Manganese. Its principal focus was to determine the nature and extension of the mining extraction and trade and exportation done illegally or without lawful authority (M.B. Shah Commission, 2012) and, as far as possible, the responsible of such illegal management. They also had to inquire into the negative impacts of mining on the Goan environment and the livelihood welfare. Finally the Shah Commission was empowered to recommend remedial measures against that business.

Hence, the Shah Commission was asked to write three reports about the illegalities done by the mining sector in the mining richest states. In the first interim report, written in July of 2011, there were some urgent remedial measures to prevent further illegal mining, its trade, transportation and export, which were considered by the Union Ministry of Mines.

V. Karnataka mining is banned: the CEC's classification of mines (2011)

The neighbouring state of Karnataka is also an important emplacement for the iron ore mining extraction. Besides, due to the Chinese mineral hunger, Karnataka (especially Bellary) has become a mining uncontrolled business place. Many illegalities have been done during the extraction, transportation and even on the commercial transactions.

In July 2011 the Karnataka Lokayukta, the state's ombudsman, reported those illegalities. In that document it was calculated the total loss to the state exchequer due to illegal activities in that sector, which was the staggering amount of 16,085 crore. Furthermore, the Central Empowered Committee (CEC) from the Supreme Court also estimated in another report that between 2003 and 2010 15,245 crore worth of iron ore was illegally exported from the state.

In fact, the CEC recommended the ban on Karnataka's mining business. But above all, it was after some state ministers were blamed to be involved in illegal mining in Bellary, the Supreme Court decided to suspend all mining operations in an area of over 10,000 hectares in Bellary.

In order to determine which mine leases could restart their activity, the CEC classified the mine leases into three categories (A, B and C) taking encroachment as the basis of the nature of offence committed (Bushan,

2013) To judge the quantum of offence, CEC has taken the ratio of the lease area of each mine to respective encroachment.

- Category A: No major encroachment outside the lease area. This does not mean this category is "clean" on other accounts. The mine operations are allowed after the reclamation and rehabilitation (R&R) plan is started.

- Category B: Encroachment up to 10 per cent of the mine lease area for mining pit and dumping of waste in area up to 15 per cent of the lease area. They have to complete R&R and pay some fines before resuming operations.

- Category C: Encroachment more than 10 per cent of the lease area and dumping of waste in area, which is more than 15 per cent of the lease area. Their lease will be cancelled and then auctioned for captive use.

Nonetheless next February, in 2012, the same CEC recommended resuming the mining exploitation in Bellary and in two other districts which were also banned. However, until two years later (in April 2013) the Supreme Court allowed the mine owners to restart their business in 90 mines in Bellary, Tumkur and Chitradurga. (Anand, 2013)

VI. M. Parrikar's Public Accounts Committee report (2011)

In 2011 Mr. Manohar Parrikar, the current Chief Minister of Goa (BJP), was leading the opposition. At the same time he headed the Public Accounts Committee (PAC) which made a report about the illegal mining in the state. Although it would never be published, due to the National Congress Party (NCP) rejection to sign it, the media covered its findings. The PAC pegged the "irregular" mining (they said in the report that it was just a euphemism of illegal) scam at 4,000 crore. The report also noticed that the lack of control over the mining management would have been the main cause of the irreversible degradation of the Goan environment and society. (Aghor, 2013)

Moreover the PAC had already affirmed that "If illegalities are not curbed immediately the legal mining also may face closure, resulting into financial crisis in the interior districts of the state" (Alvares, 2013).

VII. Shah Commission report about the illegal mining in Goa (2012)

The Shah Commission, after interacting with officials and visiting all mines for over six months in Goa, published in March 2012 the report about "Illegal mining in the state of Goa". It has tried to verify all the unlawful activities that have been done in that sector for the last decades. The report has pointed out gross violation of environment, forest and revenue laws due to mining. But, above all, the figure published by all the Indian media is the loss of 35,000 INR crore that illegal mining has caused to the public exchequer.

Notwithstanding the large amount of pages of the Shah report (832 pages in total, including the mine leases Google Earth images) its structure is, regarding to what Dr. Nandkumar Kamat wrote in Goa Today "the final

report has become very loose and confusing to read because it doesn't follow a neutral stylistics which characterize such reports" (Kamat,2012). In fact, it is the popular opinion about this document. The Shah Commission is considered a pro-mining report because it considers the mine sector as vital business for the Goan development. However, at the same time, it firmly recommends the ban on iron mining so the mine owners can fulfil all the environmental requirements for the management of the exploitation.
The ironical situation happens when the current Chief Minister M. Parrikar denies the veracity of the Shah Commission which is said to extract most of the information from the non-published PAC which he had leaded during the former legislature. (Jain, 2012)

VIII. The Goan State Government paralyzes the mining activity (10th of September, 2012)

Soon after the Shah Commission's report was submitted in Parliament, on 10th of September, the Chief Minister M. Parrikar ordered to stop temporally all mining activity in the state. Around 70% of the registered mines had been closed due to that order. What the state government really pretended was to scrutiny all the documents of the existing leaseholders to ensure only valid mine leases to operate.

Because of monsoon, this exhaustive measure was not really noticed by the population or even by the mining sector, whose activity is normally closed during that season due to the huge rainfalls that prevent the ore extraction from the pits.

IX. Union Ministry of Environment and Forest intervenes through Environmental Clearances (14th of September, 2012)

Mr. Justice M. B. Shah's findings were the justification of the Union Environmental Ministry and Forest (MoEF) to cancel 93 Environmental Clearances on 14th of September and 139 EC more four days later with the purpose of finding illegalities.

Regarding to what MoEF minister Jayanthi Natarajan told the Times of India "It (the lack of communication of state government about the mining issue) further stated that the Goa government authorities failed to take action on the communications issued by MoEF to them on the issue of violations of environmental norms by the mining units after the Shah Commission report on illegal mining was placed in public domain."

That is one of the clues to explain the relationship between Central and State government. After the elections of 2012 the Bharatiya Janata Party (BJP) party took the state government while the National Congress Party (NCP) was rolling the Union government. Therefore, the illegal mining issue was the ideal opportunity of the NCP to discredit the current Goa's Chief Minister.

X. Goa Foundation is heard: the Supreme Court imposes the ban on iron mining in Goa (5th of October, 2012)

Goa Foundation has been fighting against the mining lobby for decades. They have written to the state and central government and even to the High and Supreme Court of India in order to protect the welfare of Goan people and environment.

On the 5th of October the Supreme Court published its famous order that "all mining operations in the leases identified in the Shah Commission's report and transportation of iron ore and manganese ore from those leases, whether lying at the mine-head or stockyards, shall remain suspended, as recommended in the Commission's report".

In the same order they asked to the Central Empowered Committee (CEC) members to submit a report which has to analyse the illegalities discovered by the Shah Commission.

6. Highlights

Regarding to the initial hypothesis exposed at the beginning of that study, it is possible to state that the Portuguese Empire has been the most influent Goan regime for the mining sector, as it can be stated in every part of the environmental law, policy and management, related to the iron ore exploitation and trading. It has also been confirmed that the mining companies do not usually fulfil most of the environmental legislation and management measures of the mine lease so they are not aware about the ecological impact of their business. There have been several illegalities since its origins that could not be officially realized until last year.

Indeed, it is clear that the mining lobby, thanks also to the Portuguese, is a powerful stakeholder which has been able to direct the environmental regional planning and management through a weak submissive State Government which is also illegally beneficiating from the out of control extraction.

Notwithstanding that disappointing situation, there is a really positive conclusion that has to be noticed: the local well-informed activism in Goa is a strong tool against environmental and social injustices. Goa Foundation and other single activists have had the capacity to provoke the decisive verdict of Supreme Court about the ban on iron mining.

CHAPTER VII

DPSIR FRAMEWORK

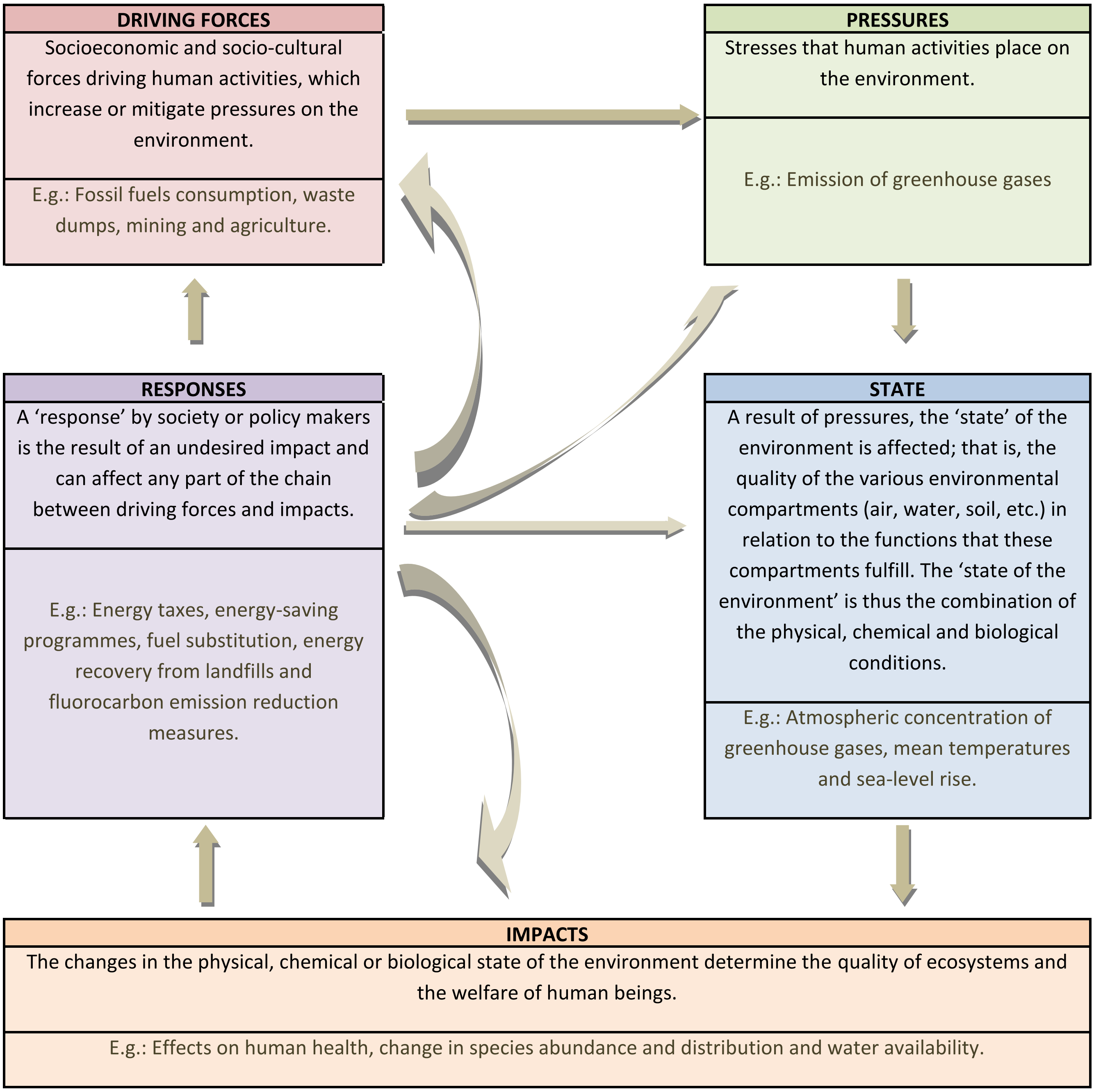
INTRODUCTION

The DPSIR represents a system analysis view: social and economic developments exert pressure on the environment and, as a consequence, the state of the environment changes. This leads to impacts on e.g. human health, ecosystems and materials that may elicit a societal response that feeds back on the driving forces, on the pressures or on the state or impacts directly, through adaptation or curative action. (European Environment Agency, 2007)

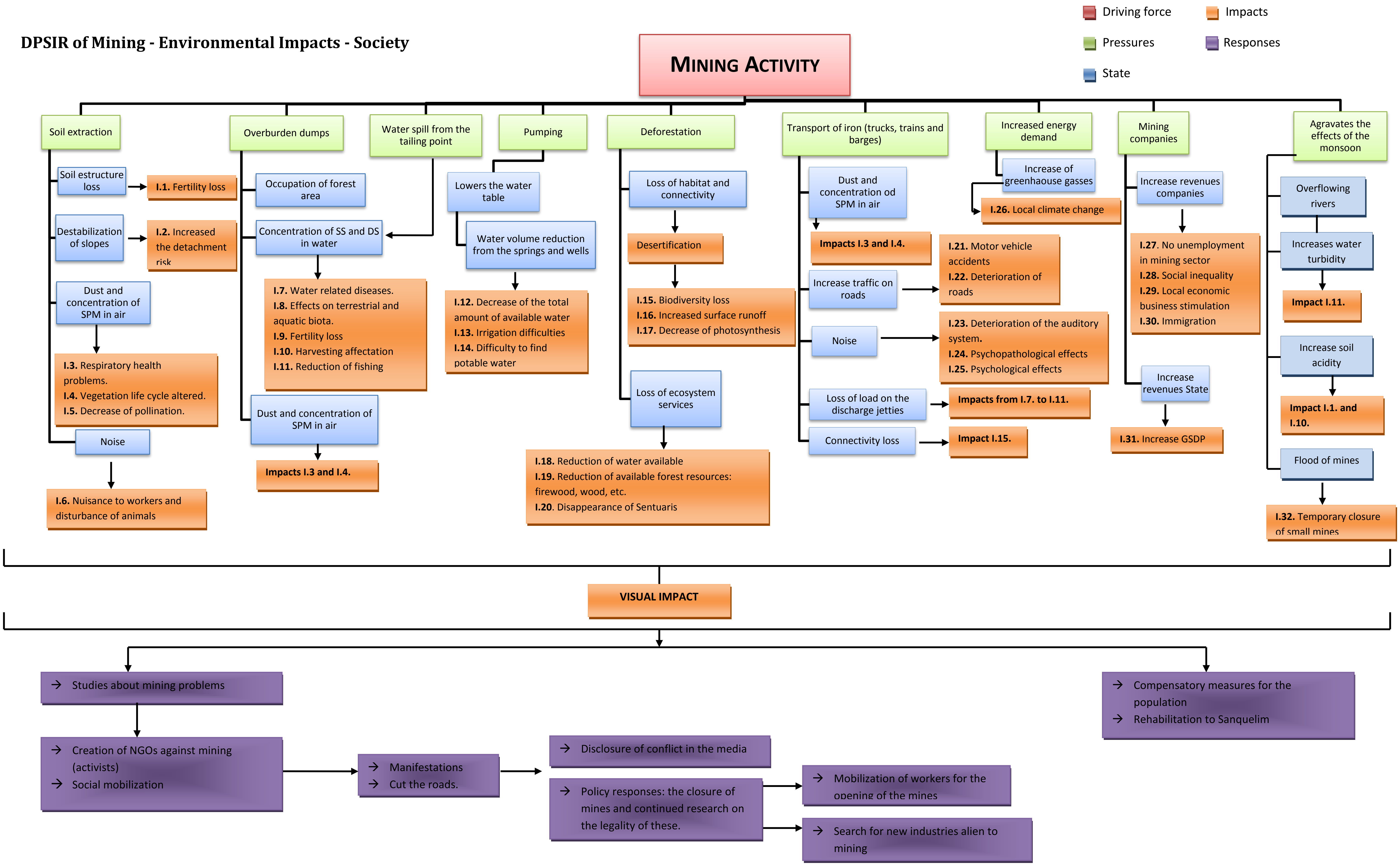
According to the DPSIR framework there is a chain of causal links starting with ‘driving forces’ (economic sectors, human activities) through ‘pressures’ (emissions, waste) to ‘states’ (physical, chemical and biological) and ‘impacts’ on ecosystems, human health and functions, eventually leading to political ‘responses’ (prioritization, target setting, indicators).

Describing the causal chain from driving forces to impacts and responses is a complex task, and tends to be broken down into sub-tasks, e.g. by considering the pressure-state relationship. Figure 7.1. is a conceptual framework that defines and shows the relations between different stages. In addition includes a simple example to be able better understand what a DPSIR.

FIGURE 7.1: DEFINITION AND EXEMPLIFICATION OF A DPSIR FRAMEWORK



DPSIR of Mining - Environmental Impacts - Society



CHAPTER VIII

SCENARIOS INTEGRATION

INTRODUCTION

Regarding to EJOLT "Scenarios are alternative images of how the future might unfold. They represent coherent and plausible stories about the co-evolutionary pathways of human and ecological systems. In other words, scenarios are internally consistent description of plausible future states of the world. Many authors maintain that scenarios are not forecasts or predictions". (EJOLT Glossary, 2010)

Therefore, the main purpose of scenario design is to create the tools for the decision-makers so they become able to have objective criteria about the different issues of the territory.

In that report, as it has been described in the methodology, the elaboration of scenarios has been made through a participative process among every member of the researching team. As a consequence, it becomes a multi-criteria vision of the mining activity in Goa. The weakness of this kind of procedure is that each parameter cannot be rated with the same range of scale. Moreover, the following handled scenarios are the second version treated by the researchers. Although it does not mean that are final because they can always be improved.

The current ban on mining has led to an exceptional situation in Goa. As a result, the state has the power to decide which path the mining industry must follow.

This section presents three possible alternatives for the future which have been proposed to assess how the environment, the socio-economic reality and material flow related to the mining sector could be affected.

On one hand, the first scenario considers the possibility that the ban on iron mining will became definitely. Therefore, the exploitation of iron ore will be stopped. However, companies could continue exporting the stock of iron ore until it finished.

On the other hand, the second scenario suggests that the iron mining will be restarted without any restriction. This situation implies the continuity of the activity, keeping pace of extraction before the current shutdown.

Finally, the third scenario would involve the reopening of mines with a cap of 20 million tons per year, which is half of what it was extracted prior to the stop.

Results

Notwithstanding this sort of multi-criteria evaluation can be criticized, it should be remembered that its main role is only assisting the decision-makers. Indeed, through this analysis could be identified the best alternative and which criteria have to be taken into account in order to evaluate the different parameters.

	Weight	THE BAN OF IRON MINING WILL BE DEFINITE	THE IRON MINING WILL RESTART WITHOUT ANY RESTRICTIONS	THE IRON MINING WILL RESTART WITH A CAP OF 20 MILLION TONES
Availability of Reserves	0.40	+1.60	-1.60	-0.80
Ground water availability	0.30	+1.20	-1.20	-0.60
Quality of water	0.10	+0.40	-0.40	-0.20
Quality of air	0.10	+0.40	-0.40	-0.30
Quality of soil	0.10	+0.40	-0.40	-0.40
Habitat	0.30	+1.20	-1.20	-0.90
Connectivity	0.25	+1	-1	-0.75
Biodiversity	0.20	+0.80	-0.80	-0.60
Ecosystem service	0.20	+0.80	-0.80	-0.60
Buffer zone	0.05	+0.20	-0.20	-0.15
Health	0.30	+1.20	-1.20	-0.60
Noise effects	0.30	+1.20	-1.20	-0.60
Traffic jam	0.20	+0.80	-0.80	-0.40
Local economic stimulation	0.10	-0.30	+0.30	+0.20
Social conflicts	0.10	-0.40	-0.40	-0.20
Mining energy uses	0.25	+1	-1	-0.50
Water consumption	0.25	+1	-1	-0.50
Waste generation	0.20	+0.80	-0.80	-0.40
Greenhouse gas emission	0.20	+0.80	-0.80	-0.40
Availability of steel plan	0.10	-0.40	+0.20	+0.30
Iron ore production	0.25	-1	+1	+0.50
Iron ore exportation	0.25	-0.75	+1	+0.50
Iron ore enterprise revenues	0.20	-0.80	+0.80	+0.40
Employment	0.20	-0.80	+0.80	+0.40
Mining contribution to GDP	0.10	-0.40	+0.40	+0.20
Active mine area	0.05	+0.20	-0.20	-0.05
Enforcement of the environment law	0.25	+1	-1	+0.50
Illegality of mining business	0.20	+0.80	-0.80	-0.60
Activist position against mining	0.20	+0.60	-0.80	-0.40
Mining lobby	0.30	+1.20	-1.20	-0.90
TOTAL		+13.75	-14.70	-7.85

- **Scenario A. The ban of iron mining will be definite**

The first scenario considers the environment as the most important issue. As it is shown on the previous table, the abiotic and biotic media are both really favoured to the mining ban.

First of all, the reserves will remain on the ground unexploited so the structure of the soil will be recovered by itself after a long. Due to the lack of activity, the ground water table is going to rise up because if there is no water pumping, the aquifers will be able to come back to the original state. Moreover, the quality of the surface water will be improved thanks to the stopping jetty discharges. In addition, the suspended particles on the area nearby the mines and roads will suffer a decrease as a consequence to the reduction of the trucks driving.

The closure of mining exploitation involves, from the outset, the end of deforestation and the encroachment of mankind and machine in the forest area. Therefore, it would ensure the continuity of local habitats and, consequently, the continuity of flora and fauna species of Goa. Moreover, the impacts generated from mining processes, such as dust, noise and water pollution would end to affect the population. Thus, population will remain and reach to equilibrium governed by the cycle of the natural ecosystem dynamics, preventing the extinction. However, a proper environmental restoration of the old mines would be required. Throughout the years, it would be possible to achieve the climax situation of the ecosystem before the mining activity.

One of the important impacts of social features is the drop of local economic stimulation, as well as, employment. In spite of the business drop, the improvement of health will be considerable in favour of social welfare. As it is mentioned before, the stopping of traffic will cause a reduction of noise as well as accidents then there will be not more social conflicts.

The material consumption will be affected because the iron ore exportations will be banned and it will bring the chance to the apparition of new consumptions as biomass... Moreover the energy uses are going to switch due to the gap leaved by the mines companies. As a result the greenhouse emissions will also decrease. In this scenario the possibility to install a steel plant is not feasible because there are not iron activities.

From the economic point of view, Goa which contributes about 50% of total Indian iron ore exports will be banned. Hence, there will be a sharply decrease on India iron ore exports. Moreover, the iron ore industry which is the second most important industry next to tourism will be also affect on Goa's GDP. Thus, the firms will not get profits from mining and the state will not receive taxes from mining. On the other hand, although at first the state would be poorer in terms of revenues, after some time other economic activities such as eco-tourism will appear. Probably, traditional activities like agriculture which were considerable affected when mining was working will restart as important industries in terms of GDP contribution. Regardless, people will lose their jobs due to the ban of mining, after some time new employment will be created.

The definitely ban on iron mining due to the Supreme Court decision in spite of the opposition of most of the main stakeholders in Goa will be the key of the future environmental enforcement. The mining lobby will not be able to influence on the governmental decisions and planning because they will have lost all it power on the region. The social activism against mining could be reoriented to other important issues favoured by this success.

In conclusion, the result of this scenario is the highest and most positive one because the importance of the abiotic and biotic issues. Moreover the political chapter goes in favour of protecting protect the environment. In addition, the minor weight of the material flow and economic features help to tip the scales to the green way.

- **Scenario B. The iron mining will be restarted without any restrictions**

This scenario describes the current situation in a long period of time where the iron mining could work without any pressure on their activities.

Related to the abiotic features, the availability of iron reserves are going to decrease because of the continuing exploitation of it. As a consequence the impacts on the soil structure are higher. Besides, the quality of ground and surface water will continue falling down due to the lack of regulation. At the same time the air pollution is still damaging the environment.

The pressure of the mining activity causes huge problems on the local ecosystem due to the deforestation and other impacts related with mining procedures. That fact involves the degradation and fragmentation of the habitat, which is strictly linked with the decline of flora and fauna biodiversity, which can lead to extinction. Moreover, the ecological services provided by the forest will not be the maximums.

The social conflict derivate from the iron management is really important and will increase every year. The reasons of those conflicts are mainly provoked by health problems, traffic accidents and noise because the trucks run over the villages all day long as well as the discharging of iron to the jetties. On the other hand, the mining activities produce a local economic stimulation and employment to the inhabitants which is an important factor to take into consideration.

Under terms of material flow the energy use is higher because of the large requirements of the mines. In addition, assuming that there is not strict legislation on this industry the energy consumption is going to grow up in the future. Therefore, there is no energy available to install a steel plant. Material consumption will be more intense and unbalanced than in the other scenarios. The greenhouse emissions will rise according to the activity.

Goa will continue producing and exporting iron ore until the reserves are exhausted. Thus, the firms will continue increasing their revenues and the taxes will be paid due to iron mining. So iron ore industry will continue as an important industry in Goa in terms of GDP contribution. Hence, the firms and the State will increase their wealth for some years.

On the political issue the passive behaviour of the State as well as the pressure of the companies give advantage to enforce the law in favour of mining activity. Supreme Court verdict does give more importance to the economic gains instead of the social problems. As a consequence the social activism against the mining will increase.

For this reason on the scenario table the result is given too much negative because the impact caused by the economic, material flow and political issue are more important than the biotic and abiotic factors. Besides the social features have not been taken into account.

- **Scenario C. The iron mining will restart with a cap of 20 million tones**

The last scenario analysis the ideal consensus between all the stakeholders which proposes a limited extraction of 20 Mt. In spite of the cap, the effects of the iron mining activity will be probably the same but in a less intense way.

The availability period of ore reserves will be extended for a short time because the iron deposits are going to be exhausted. Although there is a limit of the extraction activity over the land, the water quality and soil fertility affectation will be negative as well. However, the concentration of noxious particles due to the ore transportation will decrease.

There is no significant difference in terms of biotic environment between a limited and unlimited mining exploitation because more hectares of forest will continue disappearing if new mines are opened. The negative impacts to the ecosystem and the biodiversity will continue existing. Hence the quality of the Goan ecosystems and the biodiversity will be endangered anyway. In fact, the forest will not provide the ecological services in its maximum magnitude.

One of the most important aspects that are going to be improved is the health of the village people because it is the main social conflict source. In fact, the mining new cap will not have nearly any more effect on the people's routine.

The establishment of a cap goes in favour of other materials as biomass consumption or material for construction. In addition, the greenhouse emission will decrease so under terms of sustainability it is positive. Releasing of the energy from the extraction process could be used to install the steel factory. The researchers believe that although it requires huge energy uses, the profits for Goa will be important.

From an economical view, it will be an impact for Goa's GDP although it will be a less impact than a total ban on iron mining. The companies and the State will reduce the revenues from mining although they will continue getting revenues from this industry. Moreover, some people will lose their job but there will be an opportunity for other industries to become economic activities in Goa. Some people will return to traditional activities and new activities will be created.

As it is said at the beginning, the 20 Mt cap is the perfect agreement between the state government, the private sector and the affected village people. In spite of the mining activity will be formally controlled, it is not sure that the private sector is going to respect those limits. For example, the mine areas, in theory are not going to increase. The social activism against mining might not be cut down because of the people who do not want the iron mining in Goa.

The conclusion is that both negative and positive results of the third scenario analysis are not as high as the previous one. On one hand, in a short term, it could be a good measure because some environmental impacts are dropped. On the other hand, it has been proved that in a long term the final consequences will be almost the same as the second scenario, as it has been previously mentioned.

Methodology

Three different situations have been defined to elaborate the scenarios. In order to evaluate them from an environmental, economic and social perspective, it has been developed a table that relates the scenarios with the parameters. This method allows to quantitative assess on how the different scenarios affect the variables.

This is a sort of Multi-Criteria Evaluation (MCE) method that as the researchers know should be much more improved. In fact, it is only an illustration about the proper MCE. That method can cope with quantitative and qualitative information. For the sake of clarity, it has been decided to give quantitative points to the different criteria, and then apply an algorithm based on a simple addition. Probably that it is too simple. Moreover, a proper participative MCE would bring all stakeholders together (in our case, environmental activists, government officials, mining interests, farmer, etc.), and with their help the alternative would be established (the scenarios in our case) like the criteria (economic, environmental, social and cultural).

First of all, once the environmental impact assessment of mining in Goa has been done, it has been determined which variables are the most affected. Thereafter, to reflect the importance of each variable in the whole, it has been applied a weighting from 0 (unimportant) to 1 (very important). In order to evaluate the magnitude of impact each variable has been rated from 1 to 4 (1 = little, 2 = moderate, 3 = fairly and 4 = very much). In addition, it has been determined whether the impact is positive (+) or negative (-). Finally, to determine the total value of each scenario, the values of all variables have to be added up. The scenario that has got the most positive value has been considered the best alternative to conduct the development of Goa.

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BUDGET

EXPENSES	€/person	TOTAL GROUP (€)
Flight Barcelona - Mumbai/Mumbai - Barcelona	600	3.600
Train Mumbai-Goa / Goa-Mumbai	34	20
VISA	120	720
Hotel Mumbai (5 days)	131	786
Residence for 2 and a half month	100	600
Meals for 3 months	340	2040
Internal travel (bus and taxi)	33	200
Books and documents	/	47
Printing and binding	27.87	167.67
Researchers Salary	10 € /hour 20 h/week in Goa (3 month) = 2,400€ 20 h/5 week in BCN (5 month)= 4,000€ **800€/person·month**	38,400
		46,580€/group
		7,763 €/person

ANNEXURES

ANNEXURE 1: PHOTOGRAPHIC COLLECTION

Figure 1: **Codli mine's pit**

Source: Pablos Cascallar, Míriam

Figure 2: **Crashing plant of Iron ore**

Source: Pablos Cascallar, Míriam

Figure 3: **Tailing point of SESA Goa's mine**

Source: Pablos Cascallar, Míriam

Figure 4: **Dust on leaves of plants close to iron mines**

Source: Pablos Cascallar, Míriam

Figure 5: **Mines of Cavorem village**

Source: Vila Casau, Aida

Figure 6: **Siltation in Mulgao Lakes**

Source: Gauns, Ramesh

Figure 7: **Abandoned mine in Rivona**

Source: Vila Casau, Aida

Figure 8: **Dry wells in Pissurlem village, Sattari taluka**

Source: Gauns, Ramesh

Figure 9: **Interview with Professor Ramesh Gauns**

Source: Llavina Pascual, Xavier

Figure 10: **Information research in Goyencha Xetkarancho Ekvott's (ONG) headquarters**

Source: Pablos Cascallar, Míriam

Figure 11: **Traffic jam caused by mining trucks**

Source: Gauns, Ramesh

Figure 12: **Lost paddy field for mining**

Source: Gauns, Ramesh

ANNEXURE 2: FIELD WORK IN GOA

DATE	CITY	PLACE	ACTIVITY
23/10/12	Mumbai,Maharastra	Centre for Education and Documentation	Researching documentation
26/10/12	Mapusa, Goa	Goa Foundation	Meeting Claude Alvares
05/11/12	Panjim, Goa	Goa State Pollution Control Board	EIA, documents about water and air quality
		Town and Country Planning Department	Regional Planning of Goa
		Sesa Goa Lt.	Appointment at Codli and Samkhelim mining leases and documentation
		Goa Mineral Ore Exporters Ass. and Mineral Foundation of Goa (NGO)	Data base about mining exportation
07/11/12	Sanvordem, Goa	Codli mine	Visit to the mine and interview with Silva and Pascual
08/11/12	Sanvordem, Goa	Codli mine and Sanquelim, (SESA Goa Lt.)	Visit to the mine and interview with Joseph Cuelho, Richard Gomez and Nilesh Fernandes
09/11/12	Sanvordem, Goa	Codli mine.	Visit to the mine and interview with Bruno
13/11/12	Sanvordem, Goa	Sanvordem	Interview with John Verdes Pereira
14/11/12	Sanvordem, Goa	Sanvordem	Interview with Rajendra Kakodkar
16/11/11	Sanvordem, Goa	Goa Foundation	Meeting with Claude Alvares
23/11/12	Panjim, Goa	Goa State Pollution Control Board	Appointment with Connie
		Town and Country Planning Department	Digital Document RPG-2021
		Forest Department	Applying for information
		Directorate of Planning, Statistics and Evaluation	Appointment with Jose Veliath
		Printing press	Getting Statistical Hand Book of Goa 2009-2012
26/11/12	Panjim, Goa	Bus station	Meeting with Hanuman Porob
27/11/12	Margao, Goa	Popeye's Corner (restaurant)	Meeting with Abhijit Prabhudesai
28/11/12	Margao, Goa	Goyencha Xetkarancho Ekvott's (ONG) headquarters	Meeting with Abhijit P. Get EIA's and different information. Plan the visit to Cavorem
		Margao Garden´s	Meeting with Nilesh Gaokar
03/12/11	University of Goa, Goa	Economic campus	Interview with Pranab Mukhopadhyay
04/12/12	Bambolim, Goa	TERI center	Researching documentation in TERI's library
06/12/12	Colomba, Goa	Rama Belap house	Interview with Rama Belap
	Sanvordem, Goa	Codli mine	Interview with Joseph Coelho
08/12/12	Porvorim, Goa	Centre for Environmental Education	Interview with Sugeet Dongre, EIA information
09/12/12	Cavorem, Goa	Cavorem	Interview with Nilesh Gaonkar, visit the village and the mines (des de lluny)
20/12/12	Panjim, Goa	TERI center, Forest department and Directorate of Mines and Geology	researching documentation in TERI's library, applying for information
22/12/12	Bicholim, Goa	Ramesh Gauns house	Interview with Ramesh Gauns

24/12/12	Sanvordem, Goa	Codli mine and Mollem national park	Visit to the mine, interview with Joseph Cuelho and visit to Mollem national park
27/12/12	Mapusa Dona Paula, Goa	Goa Foundation and Rahul Basu's home	Interview with Claude Alvares and Rahul Basu
29/12/12	Bambolim, Goa	TERI center	Researching documentation in TERI's library
03/01/13	Panjim, Goa	Directorate of Mines and Geology, Forest Department and Printing Press	Applying for information
05/01/13	Panjim, Goa	Sesa Goa Lt.	Appointment with Mahesh Patil (environmental responsible of Sesa Goa)
10/01/2013	University of Goa, Goa	Geology Department	Interview with A.G. Chachadi
		Pig iron plant Amona	Interview and visit to the plant