State Disaster Management Plan (Part I of VI)

Final Report (December, 2014)

Goa Institute of Management
Ribandar, Goa

FOREWORD

Goa though blessed by not being affected by any major disaster till date is still vulnerable to the natural calamities like Flood, Cyclonic Storms, Earthquake, Landslide, Mining hazards and Sea Erosion. Apart from these natural hazards there are chances of man-made disasters like major fire, industrial accidents, terrorist attacks etc.

Goa being a small state has 2 Districts namely North Goa and South Goa and it comprises of 12 Talukas. The total area of the state is 3700 Sq. km having a population 13,43,998 with 50.23% living in rural areas and 49.7% of the population residing in urban areas.

The aim of this project is to formulate the State Disaster Management Plan, Goa, in the context of Preparedness/ Mitigation, Response & Rehabilitation from natural and man-made disasters. This Plan should be useful to tackle the multihazard vulnerabilities to population buildings livestock crop area, industries, civil facilities and infrastructure and should be based on the factors like ever-growing population, the vast disparities of income, rapid urbanization, increasing industrialization, development within high risk zones, environmental degradation, climate change, state and national security, economy and sustainable development.

The objective of the State Disaster Management Plan, Goa is to facilitate execution of activities for prevention and preparedness, response operations, coordination, rehabilitation and community awareness and involvement.

In preparing the Plan, the existing system has been studied, the prevailing documents and various stakeholders were consulted.

The framework of the plan is based on the paradigm shift in Disaster Management form a relief centric approach to a regime that anticipates the importance of preparedness, prevention and mitigation. The team has followed the guidelines for preparing State Disaster Management Plans issued by the National Disaster Management Authority.

This Plan comprises of a study of 8 disasters namely disasters originating from earthquakes, landslides, Mining, Floods, Cyclones, Nuclear, Chemical and Sea Erosion.

Acknowledgement

We extend our thanks to the North Goa collector, Smt. Nila Mohanan I.A.S. for her support and guidance in updating SDMP (December 2014). We take this opportunity to thank the former North Goa Collector, Mr. Mihir Vardhan for giving us the responsibility to prepare the State Disaster Management Plan-2009-10. Throughout the process their guidance, cooperation and suggestions helped us.

We also extend our thanks to Mr. Ashok Menon Director, Goa Fire & Emergency Services, Mr. Nadkarni Chief Engineer, Water Resource Department, Ms Radha Pamnani Chief Architect PWD, Atinho, Goa, Dr. Simon N. de Souza, Chairman, Goa State Pollution Control Board, , Mr. Vivek Marathe, Inspector, Inspectorate of Factories and Boilers, Altinho. Mr.Ashutosh Apte, Mamlatdar Disaster Management Cell and E-governance, Mr. K.V.Singh, Director Indian Meteorological Department Goa, Mr. Vivek Choche and Mrs. Veena Dhawan- IMD, Vile Parle, Mumbai Indian Meteorological Department, Dr. S Monterio-Dy. Director Directorate of Fisheries, Dr Vardhan Bhobe, Senior Surgeon, Asilo Hospital Mapusa, Mr. Mahesh Patil, General Manager- HSEC, Sesa Goa Ltd, Mr. Tanmay Saha, Deputy Manager (Terminal) Indian Oil Corporation Limited,Vasco, Mr. S. T. Puttaraju, Senior Town Planner, Mr. Swapnil Naik, Director of Transport, Mr. Michael D'souza, Director, Department of Science, Technology & Environment Also the Joint Secretary Finance, Mr. S.K. Naik, Chief Manager Fire & Safety, Zuari Industries Limited, Mr.N. M. Kantak, General Manager, Zuari Industries Limited, Mr. Suresh Sabnis, Head- Health, Safety & Security, Syngenta ; Mr. Swapnil Naik, Director of Transport, Mr.Levinson J. Martins Deputy Collector, & SDO &Sub Div. Magistrate, Superintendent Sub Jail, Mormugao, Mr. Glory Furtado – Officer- Captain of Ports, Sir S.V. Prabhavalkar, Surveyor of Works-I Central Planning Organisation, Water Resources Department. . Mr. Pramod B. Badami - Executive Engineer, Works Division I, Water Resources Department, Patto, Panaji. –Goa , Mr. Gurudas Borkar – UDC, North Goa Collectorate, and Mr.R.S.Yadav (IPS),DIGP,Goa. Dr. Sanil Kumar, Scientist – National Institute of Oceanography, Goa, Dr. Satish Shetye-Director –– National Institute of Oceanography, Goa.Dr. D. N. Sharma-Head,RSSD, BARC, Trombay-Mumbai, . Mr.Rajvir Singh, Mr. Ranjit Sharma, RSSD, BARC, Trombay-Mumbai, Mr. SA Hussain, Head-RSD, AERB, Mumbai, Mr B N Dileep and Mr Vineet Kumar-Environmental Survey Lab, Kaiga Nuclear Power Plant for their extremely valuable inputs given to us during our discussions and field visits.We also extend our thanks to Mr. Arvind Bugde,Chief Election Commissioner,Goa for his cooperation in organizing our field visit to Sankhelim and Bicholim Talukas for providing us key inputs during the visit.

We also extend our thanks to Mr. S. Sivaraman (District Informatics Officer) for his cooperation in completing the revision of SDMP (Dec, 2014). We acknowledge Dr. Shripad Kamat (Consultant Gynecologist, DHS and Master Trainer in MISP) for his valuable contribution in preparing the MISP chapter of SDMP.

Contributors

Prof.P.F.X. D' Lima, Team Advisor

Prof. Prabir Kumar Bandyopadhyay
Prof. Sameek Ghosh,
Prof. Hemant Kumar Padhiari,
Prof .Mahesh Marathe,
Prof. Rashmi Shetkar,
Prof .Aishi Sengupta,
Prof .Fernanda Andrade
Prof. Magesh Nagarajan

Table of Contents

Part I: General & Disaster Profile

Chapter 1: Introduction to Disaster Management (DM)

1.1 State Profile – Socio, Economic and Demographic

Goa has a land area of 3702 square kilometers. It is divided into two districts, North Goa and South Goa. There are 44 towns in Goa of which 14 are municipal towns and 30 are census towns (Government of Goa, 2009). Goa's population was 13.48 lakh in the 2001 census, with a sex ratio of 961 females per 1000 males (Government of Goa, 2009). All towns and villages in Goa are fully electrified. The state of Goa is located between Latitudes 15^{O} degrees, 48'00" N and between 14^{O} , 53'54" N and Longitudes 74^{O}, 40'33" E. It is 1,022 meters above sea-level. It has a land area of 3702 Sq. Kms and coast line of 104 kms. Goa is bounded on the north by Sindhudurg district of Maharastra state, on the West by the Arabian sea, on the South by Karwar district of Karnataka state and on the East by Belgaum district of Karnataka state. The highest mountain is Sonsogor in the Sahyadri range of the Western Ghats which is 3,827 feet. The Goa landscape is bisected by two major rivers that open into the Arabian sea which are as follows:

a) The Zuari which is approximately 39 miles and
b) The Mandovi which is approximately 38.5 miles.

The other major rivers include the Tiracol, Chapora, Sal and the Talpona rivers. All the rivers originate in the Sayhadri ranges and flow westward into the Arabian Sea and are navigable throughout the year. One third of Goa is covered by forests, the actual number being 1424.38 Sq kms. Of this, the Government owns 1224.38 Sq kms, the rest (approx 200 Sq km) is held by the private sector. The state of Goa has a population of 1.35 million. There are 2 districts, 11 blocks and 359 villages. The State has population density of 364 per sq. km. (as against the national average of 312). The decadal growth rate of the state is 15.21% (against 21.54% for the country) and the population of the state is growing at a slower rate than the national rate (Ministry of Health & Family Welfare, Govt. of India, 2010).

Administration

The state of Goa is the 25th state of the Union, which has a legislative assembly with a strength of 40 elected members. Goa also has 3 elected members to the Parliament. The Governor is the official head of state and is appointed by the President of India. The Chief Minister heads the council of ministers and is democratically elected and forms the government and is responsible for policies of the government during his reign. For administrative purposes Goa is divided into two districts- North Goa and South Goa with headquarters at Panaji and Margao respectively together with nine divisions and further sub-divided into 12 talukas.

Table 1.1: Goa: Demographic, Socio-economic and Health profile of Goa State as compared to India figures			
S.No.	Item	Goa	India
1	Total population (Census 2001) (in million)	1.35	1028.61
2	Decadal Growth (Census 2001) (%)	15.21	21.54
3	Crude Birth Rate (SRS 2008)	13.6	22.8
4	Crude Death Rate (SRS 2008)	6.6	7.4
5	Total Fertility Rate (SRS 2008)	NA	2.6
6	Infant Mortality Rate (SRS 2008)	10	53
7	Maternal Mortality Ratio (SRS 2004 - 2006)	NA	254
8	Sex Ratio (Census 2001)	961	933
9	Population below Poverty line (%)	4.40	26.10
10	Schedule Caste population (in million)	0.024	166.64
11	Schedule Tribe population (in million)	0.0006	84.33
12	Female Literacy Rate (Census 2001) (%)	75.4	53.7
Source: Ministry of Health & Family Welfare, Govt. of India, 2010			

1.2 Vision

To provide a resilient disaster management setup safeguarding and providing relief to the citizens of Goa.

1.3 Objectives

The objectives of this plan are to ensure that the following components of DM are addressed to facilitate community participation for preparedness, prevention & mitigation, response and rehabilitation:

1. To understand the disaster vulnerability and risks the state of Goa faces.
2. To develop a culture and operational procedure for preparedness, prevention and mitigation of possible disasters among government authorities, communities and citizens of the state.
3. Developing an early warning system mechanism backed by responsive and fail-safe communications and Information Technology (IT) support.
4. Suggesting an institutional framework through which different disasters can be addressed coherently.
5. Planning response and relief serving the vulnerable sections of the society.
6. Undertaking exercise to promote construction of resilient structures.
7. Suggesting procedure to fight post disaster psychological trauma.

Chapter 2: Vulnerability Assessment and Risk Analysis

In this chapter we have looked into the fundamental definition of disaster and its categories. An approach to distinguish between disaster and emergency has also been suggested. We have looked into the items of the Disaster Management Plan (DMP) and the disasters which has been attended in this State Disaster Management Plan (SDMP).

2.1 What is a Disaster?

A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (United Nations, 2009, p. 9).

Disasters are often described as a result of the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation (United Nations, 2009, p. 9).

Disasters can be categorized as natural, man-made and man-made natural disasters. Natural disasters are naturally occurring physical phenomena caused by rapid or slow moving events like earthquakes, landslides, tsunamis, volcanic activities, avalanches, floods, wildfires, draught, cyclones, influenza etc. Man-made disasters can be industrial accidents, transport accidents, chemical leakages, terrorism, radiological exposure etc., there are certain natural disasters which are caused by human activities, e.g. landslides are the most common natural disaster caused by human activities like deforestation, and in the case of biological disasters human beings become the carriers.

2.2 Difference between an emergency and disaster

There are considerable debates over classifying an incident as an emergency or disaster. The world community has not reached any conclusion on the distinction between emergency and disaster. Many a place disaster management and emergency management are used interchangeably. In India, where resources are scare there is a need for making a distinction between disaster and emergency is required, as responses to minor events will involve lesser mobilization.

The interchangeable use of terminology has been acknowledged by the United Nations, but they define emergency as *"A crisis or emergency is a threatening condition that requires urgent action. Effective emergency action can avoid the escalation of an event into a disaster. Emergency management involves plans and institutional arrangements to engage and guide the efforts of government, non-government, voluntary and private agencies in comprehensive and coordinated*

ways to respond to the entire spectrum of emergency needs. The expression disaster management is sometimes used instead of emergency management". (United Nations, 2009, pp. 13-14)

Clear distinction is yet to evolve, however certain parameters are suggested for consideration to distinguish between disaster and emergency. These parameters are flexible and can be made more exhaustive. The authority to call an incident a disaster should lie with the Collector of a District.

A disaster alert can be issued when the following incidents occur:

a. Evacuation siren for local villages and on-site personnel is sounded by any chemical industry.
b. Fire brigade giving a brigade call
c. Doctors, nurses, ambulances and other resources of two or more primary health centre are deployed to attend a particular incident.
d. A primary health centre invokes it's disaster management plan.
e. Tanker carrying inflammable liquid, any chemicals overturning on road
f. Water level increase beyond flood level
g. Landslides blocking state and national highway.
h. Lives of more than 9 people are at threat.
i. Landslides within 2 km radius of any village, town or city.

The above list is not exhaustive. Prudent judgment to be made by the control room of collector of each district to declare it as a disaster.

2.3 What is Disaster management plan?

A Disaster Management Plan (DMP) is a controlled document which gives details on disasters profiles, locations where it can occur, population, livestock, buildings and civil facilities which are at risk and standard operation procedure for civil authorities and elected representatives of the state.
For a state there are three levels of disaster management plans, starting with the State Disaster Management Plan (SDMP), governed by the State Disaster Management Authority (SDMA). SDMP provides guidelines to the District Disaster Management Authority for developing the District Disaster Management Plan (DDMP). The DDMP is the responsibility of the District Disaster Management Authority (DDMA). As per NDMA guideline there is a need to form municipality and panchayet level disaster management plans.

Apart from the plans mentioned above, each government department should have its own disaster management plan.

2.3.1 Disaster management cycle – Preparedness, prevention, mitigation, response, relief, rehabilitation and recovery

Disaster management involves a common set of activities. Pre-disaster activities are preparedness, prevention and mitigation. When a disaster stuck the activities are response and relief and post disaster phase recovery and rehabilitation activities are ensured. All these activities needs be seamlessly integrated to have a coherent disaster management plan, through an efficient interdepartmental and inter-organizational communication system. Protocols to receive information and disseminate the same are essential and have been dealt with the standard operating procedure of each disaster area.

2.4 Scope of the plan

This plan covers the disaster arising from floods, cyclones, chemical disasters, LPG carriers, landslides & mining, earthquakes, nuclear & radiological hazard, sea erosion and Tsunami.

2.5 Report organization

Report is divided into three parts: Part I ,Incidence Respone System (IRS) and Part II. Part I of the report consist of the vulnerability assessment and risk analysis (Chapter 2), disaster profile (chapter 3), hazard risk assessment and vulnerability mapping (chapter 4). The chapter 4 consist the state disaster management administrative framework, which is essential for the effective state disaster management. It may be noted that the nature of radiological hazard is typically different from other natural and man-made disaster. Therefore all aspects of this hazard management has been separately dealt with in Part II of the repotr,which contains individual hazard manual.

2.6 Methodology

In order to get the grasp of the present situation in terms of state's vulnerability towards different disasters, the existing organization structure, plans and documents available, the study team had detailed discussions with different stakeholders which is listed in Annexure 1: "To whom we consulted". The team has gone through the existing disasters management documents and plans available like North & South Goa district disaster management plans, state chemical emergency operation plan. Visits were made at selected panchayat and taluka levels and also have gone through the respective local disaster management plans available. The team also visited a few major MAH units and also studied some of there on site emergency plans and also collected off-site emergency plan from district authorities.
Exhaustive data was collected from different sources like NIO, BARC, Kaiga Nuclear Power Plant, AERB, and Census apart from

After studying the occurrence of various disasters in the past and vis-à-vis the vulnerable target groups and considering the potential hazards, the taluka wise vulnerability mapping has been prepared, which is presented in Table 4.1 and 4.2. Exhaustive study of various state disaster management plans, available in the public domain was also carried out. Based on the knowledge gained the state disaster management plan has been prepared, which consists of different disaster profiles, the organization structure needed at different levels as per NDMA guidelines, SOPs pertaining to preparedness, mitigation, early warning systems, relief and rehabilitation.

2.7 History of vulnerability of the state to the disaster of different types

The state of Goa is vulnerable to both natural and man-made disasters. Occurrence of flash floods coinciding with high tides is more common than river based floods. Being surrounded by hills Goa has a probability of Landslides, though past occurrences are rare, but vulnerability is not ruled out. The history of disasters are given below:

Chapter 3: Disaster Profile

3.1 Cyclones

What is a cyclone?

A "Cyclonic Storm" or a "Cyclone" is an intense vortex or a whirl in the atmosphere with very strong winds circulating around it in anti-clockwise direction in the Northern Hemisphere and in clockwise direction in the Southern Hemisphere. The word "Cyclone" is derived from the Greek, word "Cyclos" meaning the coils of a snake.

Cyclones are intense low pressure areas - from the centre of which pressure increases outwards. The amount of the pressure drop in the centre and the rate at which it increases outwards gives the intensity of the cyclones and the strength of winds.

3.1.1 Various types of cyclones

The criteria followed by the Meteorological Department of India to classify the low pressure systems in the Bay of Bengal and in the Arabian Sea as adopted by the World Meteorological Organization (W.M.O.) are:

Types of Disturbances	Associated wind speed in the Circulation
1. Low Pressure Area	Less than 17 knots (<31 kmph)
2. Depression	17 to 27 knots (31 to 49 kmph)
3. Deep Depression	28 to 33 knots (50 to 61 kmph)
4. Cyclonic Storm	34 to 47 knots (62 to 88 kmph)
5. Severe Cyclonic Storm	48 to 63 knots (89 to 118 kmph)
6. Very severe cyclonic Storm	64 to 119 knots (119 to 221 kmph)
7. Super Cyclonic Storm	120 knots and above (222 kmph and above)

Relation between kmph and knots (or m/s) for Winds is as follows:

- 1 mile per hour = 0.869 international nautical mile per hour (knot)
- 1 knot = 1.852 kilometers per hour
- 1 knot = 0.5144 meter per second
- 1 meter per second = 3.6 kilometers per hour

A full grown cyclone is a violent whirl in the atmosphere 150 to 1000km across, 10 to 15 km high. Gale winds of 150 to 250kmph or more spiral around the center of very low pressure area with 30 to 100 hPa much below the normal sea level pressure. The central calm region of the storm is called the "Eye". The diameter of the eye varies between 30 and 50 km and is a region free of clouds and has light winds. Around this calm and clear eye, there is the "Wall Cloud Region" of the storm about 5O km in extent, where the gale winds, thick clouds with torrential rain, thunder and lightning prevail. Away from the "Wall Cloud Region", the wind speed gradually decreases. However, in severe cyclonic storms, wind speeds of 50 to 60 kmph can occur even at a distance of 600 km from the storm centre. The gales give rise to a confused sea with waves as high as 20 metres, swells that travel a thousand miles. Torrential rains, occasional thunder and lightning flashes - join these under an overcast black canopy. Through these churned chaotic sea and atmosphere, the cyclone moves 300 to 500 km, in a day to hit or skirt along a coast, bringing with it storm surges as high as 3 to 12 metres, as if splashing a part of the sea sometimes up to 30 km inland leaving behind death and destructions.[1].

3.1.2 Impact of cyclones in Goa

Locations

India witnesses tropical cyclones (also known as tropical storms, hurricanes and typhoons) are cyclones which form over warm (generally tropical) ocean waters and draw their energy from evaporation and condensation. They are characterized by a strong area of low pressure at the surface and an area of higher pressure aloft. Tropical cyclones are associated with strong thunderstorms, high winds, and flooding.

Low to moderate intensity tropical cyclones bring much needed rain for agriculture around the northern Indian Ocean. But, when tropical cyclones strengthen, they can bring great loss of life and property to the region.

The state of Goa can be divided into North and South districts for administrative reasons. North Goa comprising 6 talukas with a total area of 1736 sq. kms and South Goa comprises 5 talukas with an area of 1966 sq. kms. The coastline in Goa is 105kms long and is not prone to cyclones based on past data. It witnesses gusty winds in pre monsoon or post monsoon months which can be cyclonic winds. The areas prone to such winds or any type of cyclonic activity would be along the coastline. If cyclonic activity is accompanied with heavy rainfall, then it is important to monitor whether flooding occurs in low lying areas and along coastline and take measures accordingly.

In peninsular India, cyclone occurs frequently on both the coasts i.e. The West Coast (Arabian Sea) and East Coast (Bay of Bengal) but the east coast is considered to be one of the most cyclone prone areas of the world. An analysis of the frequencies of cyclones on the East and West coasts of India during 1891- 1990 shows that nearly 262 cyclones occurred (92 severe) in a 50 km wide strip on the East Coast and less severe cyclonic activity on West Coast amounting to 33 cyclones in the same period.

The average annual frequency of tropical cyclones in the north Indian Ocean (Bay of Bengal and Arabian Sea) is about 5 (about 5-6 % of the Global annual average) and about 80 cyclones form around the globe in a year. The frequency is more in the Bay of Bengal than in the Arabian Sea, the

ratio being 4:1. The monthly frequency of tropical cyclones in the north Indian Ocean display a bi-modal characteristic with a primary peak in November and secondary peak in May. The months of May-June and October-November are known to produce cyclones of severe intensity. Tropical cyclones developing during the monsoon months (July to September) are generally not so intense. The sheer location of Goa surrounded by the Arabian Sea makes it necessary to have all the required preparedness and relief measures for any possible cyclonic activity in this area in future.

3.1.3 Occurrence of Cyclones is less over Arabian Sea as compared to the Bay of Bengal

Cyclones that form over the Bay of Bengal are either those develop over southeast Bay of Bengal and adjoining Andaman Sea or remnants of typhoons over Northwest Pacific and move across south China sea to Indian Seas. As the frequency of typhoons over Northwest Pacific is quite high (about 35 % of the global annual average), the Bay of Bengal also gets its increased quota.

The cyclones over the Arabian Sea either originate over southeast Arabian Sea (which includes Lakshadweep area also) or remnants of cyclones from the Bay of Bengal that move across south peninsula. As the majority of Cyclones over the Bay of Bengal weaken over land after landfall, the frequency of migration into Arabian Sea is low.

A comparative study showed that both the Bay of Bengal and the Arabian Sea are located in the same latitude band and receive the same amount of solar radiation from the Sun, the Bay of Bengal is much warmer than the Arabian Sea and many more storms brew over the bay. The depressions that form over the northern Bay of Bengal move northwestward across the Indo- Gangetic plains, bringing rain to most of northern India. Over the Arabian Sea, rainfall is much less on an average. The ocean plays a major role in keeping the Arabian Sea relatively dry.

Recent studies showed that there are two probable causes. (1) the winds over the Arabian Sea, are stronger because of the presence of the mountains of East Africa. These strong winds force a much more vigorous oceanic circulation and the heat received at the surface is transported southward and into the deeper ocean. The winds over the Bay of Bengal in contrast are more sluggish and the bay is unable to remove the heat received at the surface, (2) the Bay of Bengal receives more rainfall; it also receives more freshwater from the large rivers, especially the Ganga and the Brahmaputra, that empty into it. This freshens the surface of the bay and stabilizes the water column, making it more difficult for the winds to mix the warm, stable surface layer with the cooler waters below. In the Arabian Sea, there is no such stabilizing effect. As a consequence the mixing with the cooler waters below is more vigorous. Since a sea surface temperature of about 28°C is necessary for convection to take place in the atmosphere, this condition is satisfied in the Bay of Bengal but not much in the Arabian Sea.[2]

In addition to all the above the Arabian Sea is relatively colder than Bay of Bengal and hence inhibits the formation and intensification of the system.

3.1.4 History of Cyclones in the Arabian Sea:

Goa has not yet witnessed a cyclone as per the definitions described above. It witnesses gusty winds in pre monsoon or post monsoon months which have led to collapse of trees and ships / barges losing anchors due to strong winds and heavy rainfall, the past.(Data available from IMD at a a cost).

However there have been cyclones along the Arabian Sea as below. (Only severe cyclonic storms and above its intensity have been taken into account. No severe cyclonic storms were reported in the Arabian Sea during the period 1970 to 1999)

Table 3.1.1: History of Occurrence of Cyclones in the Arabian Sea

Sl No.	Year of occurrence	Impacted Region and Damage
1.	October 19-24,1975	Crossed Saurashtra coast about 15 km to the northwest of Porbandar at 0930 UTC of October 22.the storm maintained its severe intensity inland upto Jamnagar Rajkot area. Maximum wind speeds were 160-180(86-97 kts) 85 people died. The cyclone caused considerable damage to property (estimated to be about Rs. 75 crores.)
2.	May 31-June 5, 1976	The storm crossed Saurashtra coast on the morning of June 3.Maximum wind speed of 167KMPH9 90 kt) was reported by the Ship HAAKON MAGNUS. People killed 70:51 villages were affected badly:25,000 Houses were damaged : 4500 Cattle heads perished.The total damaged was estimated to be Rs. 3 crores.
3.	November 15-23, 1977	Crossed near Honavar. Karnataka and Kerala coast affected. Tidal waves were reported to have damaged 620 Fishing vessels.
4.	October 28 to November 2 , 1981	Crossed Saurastra coast close to and west of Mangrol shortly after mid-night of November 1 and moved closed to Porbandar in the early morning of November 2nd, then moving northeastwards as a severe cyclone upto Jamnagar, it weakened into a depression. About 5700 housed and about an equal number of huts were partially or fully damaged in Junagzarh, Jamnagar districts.
5.	November 4 to 9,1982	Crossed south Gujarat coasts 5 km west of Kodinagar(Veraval) 511 persons lost their lives. 12624 Pucca and 54549 Kutchha houses completely destroyed. Damage to crop to the tune of Rs. 127.23 crores.
6.	October 1-3 , 1992	Crossed Oman coast on 3rd October morning and weakened rapidly into a low pressure area over Saudi Arabia by the morning of October 5th . the system did not cause any rainfall or damage to India.
7.	November 12 -15 , 1993	Dissipated off Gujarat -Sind coast on 16th early morning. No loss of life or damage to property on the Indian territory as the system weakened over the sea itself.
	November 15-20 . 1994	Crossed north Somalia coast on the early morning of November 20. As the system hit the sparsely populated region north of Somalia, the death toll reported to be 30 only.

8.		
9.	June 17-20. 1996	Crossed near Diu between 2200 and 2300 UTC of 18th June. 33 people died and near about 2082 Cattle and 2472 people were affected in Maharashtra, 14 persons died and 1611 houses damaged
10.	June 5-9 1998	The cyclone crossed Gujarat coast north of Porbandar at 0200 UTC of June 9. The system maintained its intensity till noon when it lay over Gulf of Kutch port. Thence onwards it moved north -east wards and weakened gradually. Total lives lost 1173 and 1774 persons were missing. Losses incurred due to storm were of the tune of Rs.1865 crores.
11.	May 16-22, 1999	Crossed Pakistan coast to International Border in the afternoon of May 20. The system caused severe damage in Kutch and Jamnagar districts. Loss of life: 453: Loss of property: Rs. 80 crores. Partial damage: 5153. In Rajasthan loss of life is one. Cattle heads perished: 5104. Houses completely damaged: 50 and partially damaged: 5153
12.	November 9-12, 2009	**Cyclone Phyan** hit coast of Maharashtra, Goa and Gujarat. the cyclone 'Phyan' caused damage to lives, crops and properties in Goa and Konkan region especially in Ratnagiri, Sindhudurg, Raigad and Thane districts. About 1000 houses in these districts suffered damages. Seven persons died and 44 went missing in Goa due to cyclone 'Phyan'.
(Source: IMD)[3]		

3.1.5 Possible disasters

Low to moderate intensity tropical cyclones bring much needed rain for agriculture around the northern Indian Ocean. But, when tropical cyclones strengthen, they can bring great loss of life and property to the region.

Deep depression along with cumulative rainfall can lead to a serious disturbance leading to massive flooding, dam collapses and landslides. In Goa, a cyclone would affect fishermen and coastal villages with close proximity to the sea. Agricultural land and ports can be subject to major damage in case of a cyclone.

The dangers associated with cyclonic storms can be three fold as below:

- **Very heavy rains causing floods**

  The rainfall associated with a storm varies from one another even if they are of the same intensity. Record rainfall in a cyclonic storm has been as low as trace to as high as 250 cms. It has been found that the intensity of rainfall is about 85 cms/day within a radius of 50 kms and about 35 cms/day between 50 to 100 kms from the centre of the storm. Precipitation of about 50 cm/day is quite common with a cyclonic storm. This phenomenal rain can further cause flash flood.

- **Strong winds**

The strong wind speed associated with a cyclonic storm. (60-90 kmph) can result into some damage to kutcha houses and tree branches likely to break off. Winds of a severe Cyclonic storm (90-120 kmph) can cause uprooting of trees, damage to pucca houses and disruption of communications. The wind associated with a very severe Cyclonic storm and super cyclonic storm can uproot big trees, cause wide spread damages to houses and installations and total disruption of communications. The maximum wind speed associated with a very severe Cyclonic storm that hit Indian coast in the past 100 years was 260 kmph in Oct., 1999 (Paradeep Super cyclone).

- **Storm surges**

  Storm Surge is an abnormal rise of sea level as the cyclone crosses the coast. Sea water inundates the coastal strip causing loss of life, large scale destruction to property & crop. Increased salinity in the soil over affected area makes the land unfit for agricultural use for two or three seasons.

  Storm surge depends on intensity of the cyclone (Maximum winds and lowest pressure associated with it and Coastal bathymetry (shallower coastline generates surges of greater heights).

  It can be one of the severest destructive feature of a tropical storm is the storm surge popularly called tidal waves. The costal areas are subject to storm surge and are accentuated if the landfall coincides with that of high tides. The risk is even higher if the sea bed is shallow. Storm surge as high as 15 to 20 ft. and may occur when all the factors contributing to storm surge are maximum. This storm tide inundates low lying coastal areas which has far reaching consequences apart from flooding. The fertility of land is lost due to inundation by saline water for a few years to come.

3.1.6 Vulnerable Regions:

The regions of Goa along the coastline that may suffer the possible impact of tropical cyclones belong to the following talukas within the two districts.

- **North Goa**
  1. Pernem
  2. Bardez
  3. Tiswadi

- **South Goa**
  1. Salcete
  2. Canacona
  3. Mormugaon

Additionally, both the areas along coastline and interior regions can be affected by gusty winds which can cause damage to property, damage to crops, collapse of trees and in turn threatening lives of people including fishermen, livestock, ships and barges, boats, ships, fishing trawlers at ports.
If cyclonic winds are accompanied by heavy rainfall then there is possibility of flooding in low lying areas, in Goa. *Refer the 'Response Plan on Floods'.*

3.1.7. At Risk

Population in Goa

The people most vulnerable to hurricanes around the world include those with limited economic resources, low levels of technology, poor information and skills, minimal infrastructure and unstable or weak political institutions (Table below). Such groups are not fully able to prepare for, or protect themselves from, severe cyclones, nor to respond and cope with their effects.

Table 3.1.2[4]

Low caste communities
Ethnic minorities
Women, especially those who may be widowed or deserted
Old men and women
Children particularly girls
The disabled
People dependent on low incomes
People in debt
People isolated from transport, communication and health services infrastructure

Table 3.1.3: SOUTH GOA: Cyclone

Taluka	Population 2001 Census
Salcete	2,62,035
Mormugaon	1,44,949
Canacona	43,997

Table 3.1.4: NORTH GOA: Cyclone

Taluka	Population 2001 Census
Pernem	71,999
Bardez	2,27,695
Tiswadi	1,60,091

Table 3.1.5 Civic Facilities available Taluka wise at the cyclone prone coastal regions

Taluka	Community Bldg.	Govt. Primary Schools	PHC	Pharmacy	Govt. Hospital	Fire Station	Police Outpost	Police Station	Evacuation Centre	Relief Camp	Health Centre's & Hospitals	Village Panchayat Hall
South Goa												
Mormugao						1		2			9	
Salcete						2		4			20	
Canacona						1		1			2	
North Goa												
Pernem		15	6	11		1		1				
Bardez	5	31	18									8
Tiswadi			3							6		

(Source: Inspector of Survey and Land Records)

The above data does not indicate a fair distribution of Community Buildings, Primary schools, evacuation centers, relief camps present at the talukas mentioned in the table above. It is important to have a uniform distribution of such civic facilities, which would be used during a natural disaster example floods, cyclones or other natural calamities.

6. In line with the BMC Mumbai, mass scale sms can be sent to the entire mobile using population as a early warning mechanism to alert people for approaching cyclones or storms. This will ensure that many people will not venture out as per the advice.
7. Improve and encourage community awareness at villages, schools and colleges. Mamlatdars along with NGOs' can hold forums to inform people how they can alert authorities when they witness any unusual activity or unusual weather. Information and trainings received from NDRF can be shared with villagers and school children, so that they are aware of some useful and basic ways of been able to save themselves and others during cyclones, floods or storms.
8. Preservation of Mangroves around the coastal areas and making the area plastic /pollution free.
9. In case the NDRF is called upon for rescue operations, they should be guided by the Incident commander or by a designated officer from the Collector's office to guide them through the region affected and support them in the rescue operations.
10. Officials to be identified by the Collector's office to handle media and press releases to public by an Information Officer. This should be done in consultation with the Incident Commander and keeping in mind that public panic e avoided.
11. It is suggested to have an identified set of doctors by the various Head o Departments or Dean at the respective hospitals, medical colleges or PHC units, who would work dedicated to relief and assist in providing medical assistance during a declared disaster. These doctors would report to the ICC when a disaster strikes. During other times they would be performing routine activities as per their job descriptions.

3.2 Sea Erosion

3.2.1 What is Sea Erosion?

Every land mass on Earth has miles of coast at the interface between the hydrosphere and the lithosphere. Natural forces such as wind, waves and currents are constantly shaping the coastal regions. The combined energy of these forces moves land materials.

The landward displacement of the shoreline caused by the forces of waves and currents is termed as coastal erosion. It is the loss of sub-aerial landmass into a sea or lake due to natural processes such as waves, winds and tides, or even due to human interference. While the effects of waves, currents, tides and wind are primary natural factors that influence the coast the other aspects eroding the coastline include: the sand sources and sinks, changes in relative sea level, geomorphological characteristics of the shore and sand, etc. other anthropological effects that trigger beach erosion are: construction of artificial structures, mining of beach sand, offshore dredging, or building of dams or rivers.

3.2.2 Causes leading to Sea/ Coastal Erosion:

Human influence, particularly urbanisation and economic activities, in the coastal zone has turned coastal erosion from a natural phenomenon into a problem of growing intensity.
Human intervention can alter these natural processes through the following actions: ·
dredging of tidal entrances

· construction of harbours in near shore
· construction of groins and jetties
· River water regulation works
· hardening of shorelines with seawalls or revetments
· construction of sediment-trapping upland dams
· beach nourishment
· Destruction of mangroves and other natural buffers
· Mining or water extraction

(SAARC Disaster Management Center)[5]

3.2.3 Locations affected:

The Indian coastline is about 7517 km, about 5423 km along the mainland and 2094 km the Andaman and Nicobar, and Lakshadweep Islands. At present, about 23% of shoreline along the Indian main land is affected by erosion.

The state of Goa has a 105km long coastline and as per the table below 10.5km of coastline has been affected by sea erosion. Erosion has been observed at Anjuna, Talpona, Sinquerim, Coco beach, Colva and Betalbatim

Table 3.2.1 [6]

State	Sandy beach (%)	Rocky coast (%)	Muddy flats (%)	Marshy coast (%)	Total length* (km)	Length of coast affected by erosion** (km)
Gujarat	28	21	29	22	1214.7	36.4
Maharashtra	17	37	46	–	652.6	263.0
Goa	44	21	35	–	151.0	10.5
Karnataka	75	11	14	–	280.0	249.6
Kerala	80	5	15	–	569.7	480.0
Tamil Nadu	57	5	38	–	906.9	36.2
Andhra Pradesh	38	3	52	7	973.7	9.2
Orissa	57	–	33	10	476.4	107.6
West Bengal	–	–	51	49	157.5	49.0
Daman and Diu					9.5	–
Pondicherry					30.6	6.4
Total mainland	43	11	36	10	5422.6	1247.9
Lakshadweep					132.0	132.0
Andaman and Nicobar					1962.0	–
Total					7516.6	1379.9

*According to the Naval Hydrographic Office.
**Information collected from respective states.

CURRENT SCIENCE, VOL. 91, NO. 4, 25 AUGUST 2006

3.2.4 Possible disasters

Sea/Coastal erosion occurs when wind, waves and long shore currents move sand from the shore and deposits it somewhere else. The sand can be moved to another beach, to the deeper ocean bottom, into an ocean trench or onto the landside of a dune. The removal of sand from the sand-

sharing system results in permanent changes in beach shape and structure. The impact of the event is not seen immediately as in the case of tsunami or storm surge. But it is equally important when we consider loss of property or damage to land/crops due to saline water seepage in soil. It generally takes months or years to note the impact of erosion; therefore, this is generally classified as a "long term coastal hazard".

3.2.5 At Risk –Locations in Goa

Coastal erosion, or coastal instability, threatens property and businesses and puts people living near cliffs and shorelines at risk. The great concentration of national resources in coastal zones makes it imperative that coastal change is well understood.

Along the coastline of Goa, sea /coastal erosion has been observed on the beaches Siolim, DonaPaula, Talpona, Anjuna, Betalbatim, Utorda and Pollem beach. Additionally, according to a study by the National Institute of Oceanography, the beach along the Candolim-Sinquerim coast has been affected by erosion due to the grounded super tanker M.V. River Princess and has made recommendations like a beach nourishment program to counter the sea erosion.

The coastal protection works in the last few years have built coastal protection structures like:

- Laterite sea wall at Siolim
- Wall structure at Dona Paula beach
- Granite Armour stone at Talpona beach
- Temporary structure at Betalbetim beach

In an attempt to minimize the risk, the Ministry of Environment and Forests, Government of India, has created a statutory innovation in the form of a legal notification for the protection and planned development of coastal areas, including the reservation of areas in coastal zones set aside as No-Development Zones. The notification actually crystallises a fairly firm policy that had extended over a decade to protect coastal areas from unplanned and indiscriminate human activities. On 19 February 1991, the Ministry of Environment and Forests issued an elaborate notification called the Coastal Regulation Zone (CRZ) Notification which sought to regulate human activities in the area of 500 m from the High Tide Line (HTL) along the coastal stretches of the country. The CRZ Notification came into immediate effect on the same day and was made applicable to the entire 6,000 km coastal belt of India and, in addition, to riverine stretches affected by tidal action. The objective of the CRZ Notification is to protect the coastal areas from becoming degraded due to unplanned and/or excessive development which results in pollution and the eventual destruction of this highly prized, fragile and irreplaceable natural resource.

The importance of the CRZ Notification is even higher in case of damage due to coastal/ sea erosion to property and human life. Development activities around the coastal areas should be closely monitored by the State Government so the CRZ rules are not violated and loss to property/human lives due to sea erosion can be minimized.

Preservation of mangroves also assumes significance for Goa to reduce impact of sea erosion and will lead to delay in flooding. Emphasis can be laid to avoid pollution and plastic around the mangroves for them to survive in coastal areas.

As per a recent report in the Times of India dated 25April 2010 , the MOEF has sought mapping of eco-sensitive low-lying areas under tidal flushing, especially khazan lands, and protection and management for them and mangroves and further through a proposed a proposed amendment in the Coastal Regulations Zone (CRZ) notification 2010, seeks to survey and map Sand dunes, beach stretches along bays and creeks "No commercial activity shall be permitted on such sand dune areas", has been stated in the proposed amendment.[8]

Sea/ coastal erosion cannot be termed as a disaster posing immediate threat to property and human lives. It brings about damage to the coastal areas over a long period of time and in turn affect tourism in context of Goa.

Recommendations:

Sea Erosion is a natural phenomenon and cannot be prevented as coastal land gets either silt deposited or eroded around the coastal regions all around the globe. Preparedness measures can be adopted and implemented to manage it better as the erosion takes place over a long period of time and not over a few days. Proper analysis and preparedness will help contain damage to property, crops and land. Experts at NIO state that sometimes to do nothing about sea erosion is also advised to allow nature take its own course. However, measures need to be adopted in case of large scale erosion which impact to human settlements, crops and erosion due to man made reasons should be tackled to reduce impact.

1. Sea Erosion does not necessarily have immediate damage to human lives caused overnight and hence it calls for proper analysis and the appropriate measures to counter damage.
2. Appropriate measures decided by administrative authorities might lead to protests from local villagers, fishermen and this call for public awareness on the measures to be adopted and the long term benefits. Public awareness can be done in liaison with NGOs and administrative authorities. It is desirable to have larger community involvement in such activities.
3. The measures should not be such that it leads to coastal pollution due to failure to control erosion.
4. Preservation of Mangroves around coastal belt of Goa and keep the mangroves plastic free.
5. Improved Inter departmental coordination/communication and shared responsibility can lead to better management of sea erosion activities.

3.3 Flood

3.3.1 Introduction

Floods are indeed a part of the earth's natural water cycle and have been accruing right from the beginning. In fact earth's geography has time and again been altered by floods and changing courses of major river systems. However, the damage due to flood has tended to increase with time due to greater interference by man in natural process and encroachment of flood zones and even riverbeds by human beings.

Occurrence of floods is as old as the rivers and the hills themselves. The earliest references to floods are found in the Rigveda and to the "Deluge" in the Old Testament. They were believed to be divine punishment meted out to humans for their cause widespread devastation even now. It is recognized

that floods are a natural phenomenon, which cannot be entirely eliminated. Man has, therefore, to learn to live with the floods and where possible, rectify the ecological mistakes.

The term "flood" denotes both the discharge of a river under condition of excessive rainfall and the inundation of low lying areas. It has been observed that floods in rivers have certain characteristics, depending on the topography, meteorology and hydrology of the regions through which the rivers flow. Some rivers are erratic in that they often change their course.

Floods are classified as downstream and upstream floods. The downstream floods are most spectacular and damages are more apparent and hence the upstream floods are not taken adequate notice of.

Floods may be caused in rivers by excessive downpour in their catchment areas. They may also be caused by cloudbursts in a specific area. In the case of river floods preventive measures can be undertaken. Since floods in the latter case cannot be anticipated, preventive measures are difficult to undertake. This distinction between the river floods and the cloud burst floods need to be borne in mind in relief administration.

3.3.2 Causes of Floods

In its strictest sense, a "river in flood" means overflowing of its water into the surrounding countryside. The height of the banks and consequently the flow of water may vary greatly within comparatively short stretches. The floods are caused due to the following factors:

(1) Extra-ordinary heavy precipitation concentrated in the catchment over a period of few days;
(2) Choking of the bed of the river with heavy detritus and the consequent change in the river course;
(3) Artificial obstruction to natural river flow like inadequate waterways provided on railways or road bridges or road embankments.

Causes at micro level

Different causes at the state level are enumerated below,which was emerged at the time of discussion with different stakeholders during field visits at Bicholim, Sankhelim & Canacona.:

1. High intensity of precipitation resulting from cloudbursts.
2. Release of waters from the dam.
3. Silting of river.
4. Effects of High Tides.
5. Meandering or curves on the path of the river.
6. Bottlenecks or encroachments on path of the river.
7. Degradation of forests or area in catchment area resulting in flash floods.

3.3.3 River Systems And Reservoirs at Goa:

Major Rivers in North Goa

1. **Terekhol**
2. Chapora
3. Mandovi

Tributaries of Mandovi River

- Madei -- Kudne
- Surla – Valvant
- Kotrachi – Bicholim
- Ragda – Assonaora
- Khandepar – Sinker

Minor River in North Goa

Baga River

Valvanta River

- The Valvanta river originates near Virdi village in Sawantwadi Taluka of Maharashtra. It is known at Haltar nallah or Virdi river in Maharashtra.
- The river transverses a length of 12.50 kms in Maharashtra and enters Goa near Shiroli Village in Sattari Taluka.
- It flows for another 4.00 kms in Goa where it is joined by Costi Nadi on which Anjunem Dam is built.
- The river transverses another 8.50 kms upto Sanquelim Town.
- The river flows another 6.00 kms upto its confluence with Kudnem Nadi and Bicholim river and the meeting the Madei River
- The Valvanta River is prone to tidal variations upto Sanquelim Market.
  The river is meandering in nature and the catchment of the river is fan shaped.

Plan of Valvanta River

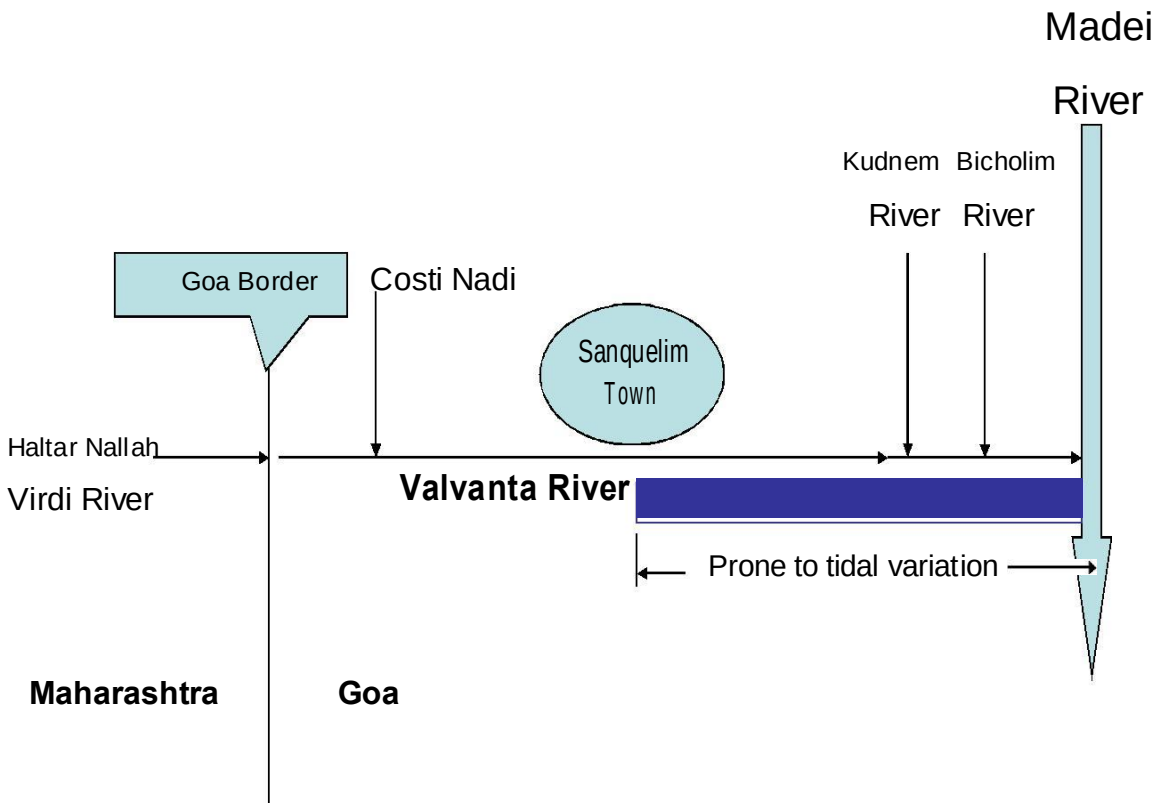


Figure 3.3.1

3.3.4 Floods and Rainfall history of Goa

Heavy Precipitation

- There was heavy precipitation in the catchment on Thursday i.e. 27.09.2007.
- The details of the intensity and duration of precipitation is being ascertained especially in the catchment in Maharashtra and Karnataka.
- Heavy precipitation is the most probable cause since heavy flood discharges were noticed after 8.00 p.m. from Virdi river and by 8.30 p.m. on 27th the river was flowing 1 mt above the Goteli Bridge.

- The state witnessed heavy rains accompanied by gusty winds on 26th June,2010 nignt and 27th Morning,June,2010 causing water logging and land slides in various places.The state Meteorological observatory recorded rain fall of 234.6mm during 24 hours ending early 27th June,2010.(Navind Times 27.06.2010)

Releases from Dam

- The Anjunem Dam is constructed on Costi Nadi and has a reservoir capacity of MCM. The reservoir normally gets full by end of July and upto this time the flows from the Costi river are arrested by the Dam.
- When the Dam reaches Full Reservoir Level, a buffer of 1.00 mt is kept upto mid-October for routing of flood discharges in Costi river which is the gradually reduced for reservoir to get full by end of season since the reservoir caters for irrigation and drinking water needs.
- On 27th of September, being the end of the season, a buffer of 0.30 mts was kept in the reservoir and the flows of costi river were regulated to release the maximum discharges during low tides.
- During high tides discharge of about 80.00 cumecs was released from the dam whereas during low tides the same was reduced to the maximum possible by keeping the reservoir level at FRL of the dam. The safety of the dam is of paramount importance and the same was also kept in mind for regulating the flood discharges through the dam reservoir.
- No waters from reservoir were released into the river as has been made out, but only the discharges of Costi Nadi were regulated through the Dam.

Flood Routing through Dam

Meandering & Silting of the River

- The Valvanta river is a meandering river and the many a times has changed its course during its life cycle.
- The meandering nature of the river and the swift flow of the river has resulted in carrying huge silts/ eroded material from the catchment and depositing the same along the curves of the river.
- The siltation of the river has resulted in reduction of flow area and this may be one of the causes of the flooding.

Effect of High Tides

- The Valvanta River is prone to tidal variations upto Sanquelim Town.
- The heavy precipitation in conjuction with high tides results in afflux or rise in water level which leads to flooding.

- On 27th of September, the high tide which occurred at 11.30 p.m. was main factor in flood discharges overtopping the banks and embankment at Sanquelim

Bottlenecks or encroachments in river

- There are no major encroachments in Valvanta River regime.
- However some bottlenecks are existing in the river especially at Makarsheni where the width of the river reduces and the river is in tidal zone.
- There is a need for improving the hydraulics and the regime of the river.

Degradation of Forests & Catchment area

- This may be a probable cause and should be ascertained.
- The main catchment area is in Maharashtra and the position of the catchment in Maharashtra and Karnataka is being ascertained.

Proper catchment area treatment is needed if the same is found wanting.

Flood Control, Anti -Sea Erosion and Drainage Works

1) Goa experiences a heavy rainfall from South West Monsoons. The heavy intensity precipitation in conjunction with high tides in the monsoons create drainage congestions in low lying areas resulting in flooding of the said areas. Hence Flood Control Measures like embankments, flood retaining walls et al are undertaken to reduce or mitigate the flooding problems experienced in the State.
2) Goa has a long coastline of 105 kms and at many places sea erosion is experienced for which various anti sea erosion measures like sea walls, concrete blocks etc are envisaged to reduce the damages.
3) Works are undertaken to improve the drainage conditions of nallahs and rivers.

The position of works as on December 2008 and taken up during 2008-09 and proposed programme for year 2009-10 is as follows:

Table 3.3.1

No	Scheme	In progress		Proposed		Targets(08-09)		Targets(09-10)	
		Nos	Lakhs	Nos	Lakhs	Kms	Lakhs	Kms	Lakhs
1.	Flood Control Works	27	327.100	17	611.98	10.00 10Ha.	939.08	12.00	3822.00
2.	Anti Sea Erosion Works	11	288.37	8	1260.00	2.50	1548.37	2.50	1646.00
3.	Drainage	46	388.07	23	1371.58	7.50	1759.65	8.50	714.00
	Total	84	1003.54	48	3243.56	20.00	4247.10	23.00	6182.00

The lower parts of the river basin are more at risk as compared to higher areas of various river basins in Goa.

The erratic and temporal occurrence of floods in Goa adds to the difficulty of formulating a system. Documentation and analysis of flood damage and losses would be major exercise in itself cataloguing of flood prone areas.

3.3.5 Rainfall

The average normal rainfall of India is about 883 mm, whereas the average normal rainfall of Goa is 2500 mm. Annually mostly during June to September period, which is drained by an extensive network of waterways. There are six important rivers namely mandovi, Zuari, Sal, Terekhol, Chapora & Talpona.

The Indian Meteorological Department (IMD) / Water Resource Department (WRD) has been maintaining one Meteorological Centre for collection of meteorological data on uniform scientific lines, and issues daily bulletin of weather forecasts for whole Goa. The routine monitoring of rainfall and tank water level during the monsoon season is a important task for ID&R, Irrigation Unit in Goa. At present it depends largely on voice communication by telephone or wireless and production of daily report is entirely manual.

Clarifications in respect of terminology used by the meteorological department in rainfall.

(a) Heavy rainfall will imply expected rainfall between 65 mm. to 124 mm. in 24 hours in the specified area.
(b) Very heavy rainfall will imply expected rainfall 125 mm. or more in 24 hours in the specified area.
(c) For special distribution terminology used is given below:

Terminology used Percentage area coverage under specified weather
Isolated : 1 to 25 per cent.
Scattered : 25 to 50 per cent.
Fairly wide spread : 51 to 75 per cent.
Wide spread: 75 to 100 per cent.

Heavy rains - Heavy-rains would normally mean rainfall above 125 mms. within 24 hours, as decided by the Meteorological Department and flood central authorities. However, criteria to be adopted for grant of relief to the persons, affected by heavy rains should not merely be physical dimensions of the rainfall, but the fact of actual damage caused to the community and the persons concerned. Persons affected by heavy rains are eligible to receive relief in the State hereafter mentioned.

Table 3.3.2 Rainfall in Goa Recorded from 1991 – 2008

Year	In MM	Year	In MM
1991	2152.3	1999	3680.4
1992	2778.2	2000	3511.6
1993	2558.3	2001	2128.1
1994	2894.4	2002	2270.4
1995	3555.6	2003	2686.9
1996	2880.9	2004	2156
1997	3366.9	2005	3345.1
1998	3078.9	2006	2109.6
		2007	3689

Source ; Goa Observatory, Panaji.

Water Carrying Capacity of River :

There are no regular Gauge & Discharge Stations on rivers in the North Goa. However, the flood-level observations are made during monsoons on some rivers. Details of these observations are given below:

Table 3.3.3 Details of Observation Centres

Sr. No.	Name of River/Stream	Location of Flood Observation Station	Warning Level RL, Mts	Danger Level RL, Mts	High Flood Level RL Mts
1	Madei	Ganjem Village, Ponda Taluka	9.500	10.500	12.520
2	Veluz	Valpoi, Sattari Taluka	99.000	100.000	101.000
3	Gotoli Nalla	Gotali, Keri, Sattari Taluka	99.000	100.000	102.000
4	Bicholim	Shantadurga School, Bicholim	4.300	5.200	6.200
5	Bicholim	Near Kadamba Bus Stand	4.300	5.200	6.200
6	Valvanta	Sankhelim Market	2.900	4.400	8.200
7	Valvanta	Near Datta Temple Sankhelim	5.100	6.100	7.800
8	Kapileshwari Nalla	Khadpabandh Road Culvert, Ponda	98.365	98.665	98.965

Method of data recording of rainfall:
Various methods of data recording are as under:

Ordinary Rain gauges: The daily data at these stations are being collected manually. Only two observations are taken daily at 8.30 & 17.30 hrs. But this frequency of data observations is not adequate for rainfall behavioural studies.

River Gauging Stations: These are usually a series of gauges at different locations across the riverbed. Observations are taken two hourly during the monsoon season, by noting down the levels manually on gauges fixed in the riverbed. The "Slope Area Method" calculates discharge and finally daily/monthly flows are computed.

Meteorological observations: The Conventional Meteorological Stations have been set up to observe the minimum and maximum Temperatures, Wet & Dry bulb for humidity, Wind direction & velocity and Sun shine hours.

Modernized data recording system: Water resource projects are executed not only for Irrigation purposes in modern days but are also planned for other purposes, particularly for Domestic and Industrial Water Supply, producing Hydro-Electric Power, Navigation, recreation, fishing, wild life as well as flood control etc. There has been significant development in the country in this field and new techniques, methodology and latest designs have been developed in order to design suitable project. A successful Water Management requires various types of vital hydrological data as mentioned below:

1. Hydro-meteorological data
2. Stream flow data
3. Sediment data
4. Ground Water data
5. Water quality data
6. Miscellaneous data i.e. Topography, soil etc.

The main deficiency had been the lack of establishment of a properly designed data collection network and data storage and retrieval system to provide scientifically based hydrological and meteorological data of required quality and quantity for different purposes. The data collection activities in the field are mostly based on manual observations at almost all observation sites in Goa.

Therefore, a project for modernization of Hydro meteorological Observations and Network using latest technique/instruments in Goa is very urgent requirement.

3.3.6 At Risk

Everything located in Flood plans.

Crops, Livestock, Machinery, Equipments, Infrastructure, Weak Buildings, Their Contents, People & Local Community.

Area & Administrative Set-Up

1) Sub-divisions :
   3 Nos. In South (Margao, Mormugao & Quepem)
   5 Nos. In North (Panaji, Mapusa, Bicholim, Ponda & Pernem)

2) Talukas : 11 nos (Districts – North & South)
North – 6 Nos. (Bardez, Bicholim, Pernem, Ponda, Sattari & Tiswadi)

South - 5 Nos. (Salcete, Mormugao, Sanguem, Quepem)

3.3.7 Flood Prone Areas:

Flood in urban areas can occur during monsoons due to faulty planning, choking of drainage systems and unplanned growth or settlements.
State of Goa has faced situation in the past. The flash in Canacona, Bicholim and Sankhelim many other places caused heavy damage. Flood prone districts and areas in the State are given in the Table 4.1 and 4.2 for both the districts.

3.4 Land Slide

3.4.1 INTRODUCTION

Figure 3.4.1

Figure 3.4.1 – Landslide at Porvorim on NH-17 opposite to the Goa Assembly Complex (September 8, 2007)

Definition

A landslide is the movement of soil, rock, or other earth materials, downhill in response to gravity. Landslides include rock falls and topples, debris flows and debris avalanches, earthflows, mudflows, creep, and lateral spread of rock or soil. Frequent landslides occur in areas where the soil is saturated from heavy rains or snowmelt. They can also be started by earthquakes, volcanic activity, changes in groundwater, disturbance or change of a slope by man-made construction activities, or any combination of these factors. A variety of other natural causes may also result in landslides, and they may trigger additional hazards, such as tsunamis caused by submarine landslides. A landslide occurs when the force that is pulling the slope downward (gravity) exceeds the strength of the earth materials that compose the slope.

The Causal Phenomena

The down slope transport of soil and rock resulting from naturally occurring vibrations, changes in direct water content, removal of lateral support, loading with weight, and weathering, or human manipulation of water courses and slope composition.

General Characteristics

Landslides vary in types of movement (Falls, Slides, Topples, Lateral Spread, Flows), and may be secondary effects to heavy storms, earthquakes and volcanic eruptions. Landslides are more widespread than any other geological event.

Falls – Falls are masses of rock and/or other material that move down slopes primarily by falling / bouncing through the air. They are common along steep road or railway cuttings and along steeply undercut cliffs in coastal areas. Large individual boulders or blocks or rocks can cause considerable damage to houses or roads located at the base of the slope.

Topple – Topple is an overturning movement that, if not blocked by other masses, will result in a fall or a slide.

Slides – Slides result from shear failure along one or several surfaces. The slide materials can be broken up and deformed – or remain fairly cohesive or intact. A cohesive landslide is called a slump movement on both sides and slumps are controlled primarily by pre-existing structural features such as faults, joints and bedding. **Rotational slide** is where movement involves turning along a point and **Translational slide** is where movement is predominantly along planner or gently undulating surfaces.

Lateral Spread – A Lateral Spread or Earth Spread is a lateral movement of a fractured mass. Horizontal movements are commonly as much as 10 to 15 feet, but, when slopes have the adequate angle, lateral movements can be as much as 100 to 150 feet. Some spreads are without a well defined basalt shear surfaces; others include extension or rock or soil resulting from liquefication or plastic flow of subjacent material.

Flows – The movement of flows resemble that of a viscous fluid, and slip surfaces are almost non-existent. Flow can take place as one or more lobes that move at different rates depending upon the viscosity of the material and local slope angle. Most flows occur during or after periods of heavy rainfall, when the cohesiveness of soil and the bonding of the soil by clay minerals break down, permitting down slope flow even on fairly gentle slopes. These landslides can move rapidly and cover distances of several miles along available drainage paths.

3.4.2 Goa and its Geological Make-up

Geology

Two aspects of Geology are very important:

1. **Lithology –** This include the composition, fabric, texture or other attributes that influence the physical or chemical behaviour of rocks and soils. These attributes are very important in determining the shear strength, permeability, susceptibility to chemicals and physical weathering and other characteristics of rock and soil materials, which in turn affect stability.

   Among important characteristics of solid constituents of sedimentary rocks are size, distribution, shape, area, surface characteristics and mineralogy of the rock or mineral particles, the amount and kind of cement, and the mechanical strength of particles and the cement.

   In fine-grained sedimentary deposits, the relative abundance of clay minerals, the clay mineralogy, inter particles bonds and the presence and chemistry of water are dominant compositional factors influencing slope stability.
2. **Structure of Rocks and Soils** – Structure includes the features of inhomogencity and discontinuity in rocks or soils, at scales larger than a hand specimen, including the sequence of different layers, altitude of layering, gross changes in lithography, bedding planes, joints, faults and folds. These factors are important as a group.

Geomorphology

The most important geomorphological characteristic to be considered is the presence or absence of former landslides, for such evidence of past instability is frequently the best guide to future behaviours in the locality. Steepness of slope in relation to the strength of slope-forming materials is very important. The interrelation between slope gradient and stability, however, is not simple. Many steep slopes of competent rock are more stable than comparatively gentle slopes of weak material. Slope aspect i.e., the direction in which a slope faces, and its curvature both down slope and across slope, may also be related to slope stability.

Hydrology and Climatology

Water is the main factor in slope instability. Identification of the source, movement, amount of water and water pressure is as important as the identification of the different soil and rock layers.

Types and severity of slope failures differ very markedly from region to region depending on the climatic patterns of temperature and precipitation, and upon the soils and weathering products characteristics of each climate region in temperature regions having moderate rainfall, seasonal fluctuations of groundwater flow and pressures may lead to periodic activation of deeper slides.

Vegetation

The effect of vegetation on slope stability appears to be complex, even though the vegetative cover definitely promotes stability. A forest protects the surface from weathering actions of sunshine, rain and winds, and retains considerable amounts of water by wetting the large vegetation surface.

Vegetation cuts down on water runoff and erosion while the root system may increase the shear resistance of the mass and may increase the soil cohesion by creation of negative pore pressures.

On the other hand trees may export deleterious effects by their load and the load of retained water on soils of steep slopes, by the mechanical action of wind forces transmitted to the soil by trees, felling of trees and propagation of failure under strong seismic motion, and the wedging action of tree roots which widens fracture and promotes infiltration.

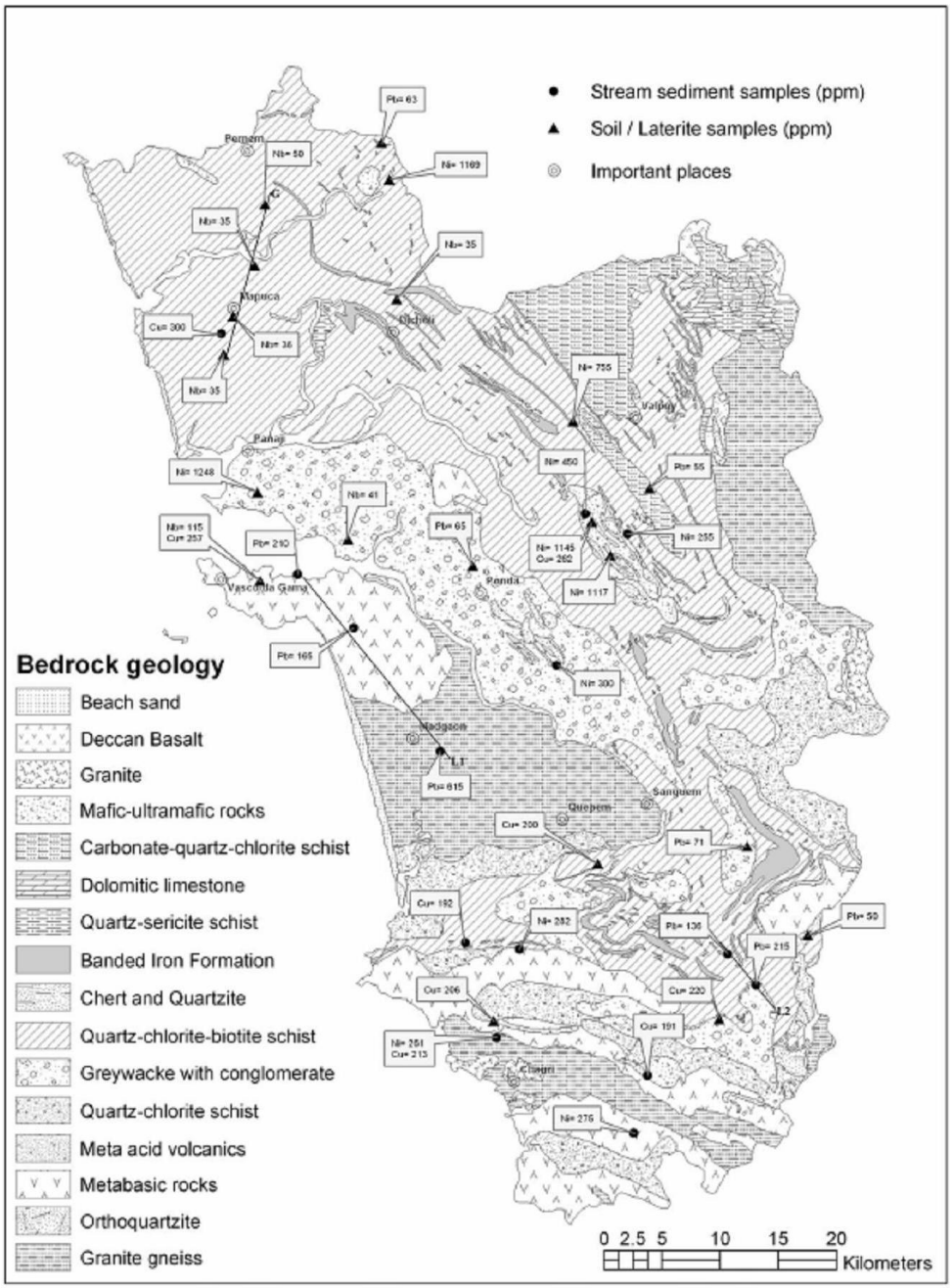


Figure 3.4.2– Geological Map of Goa

The coastal state of Goa lies on the West Coast of India with a coastline stretching for its entire length of over 100 kms., the State is broader towards the North. 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
- steep slopes of the Western Ghats on the eastern border of the state

1. **The Western Coastal-Estuarine plains with Tablelands**: This terrain consists of low-lying 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 lower 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 metres high) laterite topped plateaus (tablelands). These tablelands often form rocky headlands abutting the seafront and between them lie the sandy beach stretches of the low lying coastal plains. In the far South of the state (the Quepem and Canacona coast) the coastal estuarine plains are much smaller, isolate and limited in extent. Here the terrain is often hilly and mountainous even near the coast.

2. **The Central Undulating Region (Midlands):** This region is made up of relict 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 hills and valleys of this undulating region are generally aligned (elongated) in a NW-SE direction (as are the Western Ghat ranges 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 in NW-SE. The coastline of Goa is also NW-SE and therefore the inland hill ranges remain almost parallel to the coast.

   However, in South Goa the structure of the underlying rock formations is WNW-ESE and therefore the hill ranges and the ghats have a trend closer to East-West. As the coastline is almost North-South the East-West trending hills and ridges encounter 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.

3. **The Western Ghats:** This hilly region consists of steeper and higher ranges (600 to 1000 meters high) and covers the Eastern and Southern portions of Goa. 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 hills, which is related to the underlying rock structure, is almost East-West (WNW-ESE). Here, a western arm of the Ghats (the Karmal Ghat) literally meets the sea in its lower reaches. As a result, the talukas of Quepem and Canacona have very limited of the coastal estuarine plain and the midland region translates very sharply into ghat region.

All the rivers that flow within the state are estuarine (rias or estuaries), the tidal waters reaching several kilometers inland. Between the Sahyadris and coastline, the relict landforms of the plains and those of the midlands are dissected by these estuarine systems. The rivers originate in the Western

Ghat range but soon lose their energy as they meander through the midlands and estuarine plains before meeting the sea. These estuaries include the Tiracol, Chapora, Mandovi, Zuari, Sal, Talpona, Galgibag and a few smaller coastal inlets.

3.4.3 Landslide Hazard Zones of Goa

Figure 3.4.3 Landslide Hazard Zonation Map of India

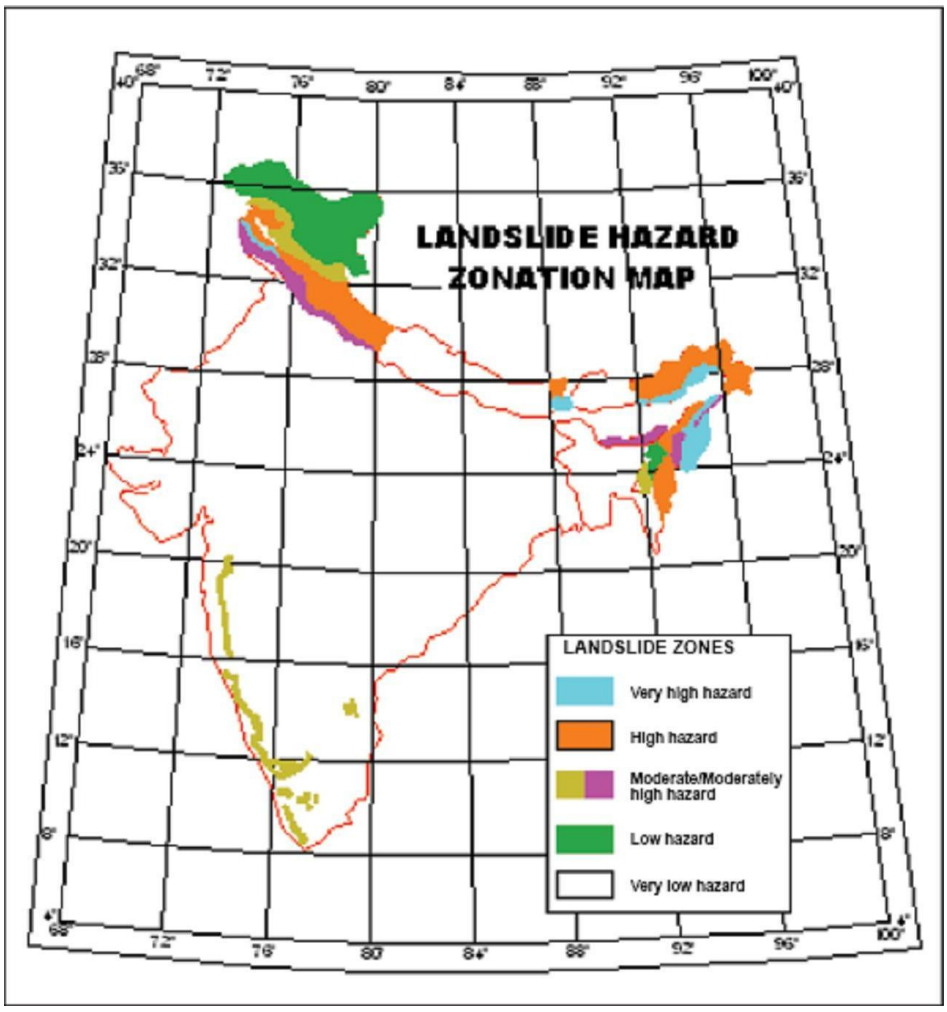


Figure – Landslide Hazard Zonation Map of India (Prepared by GSI)

Landslide Hazard Zonation Mapping

The aim of Landslide Hazard Zonation mapping, which is needed for risk assessment, is to determine the spatial and temporal extent of a landslide hazard. In general the LHZ map divides the landslide

prone hilly terrain into different zones according to the relative degree of susceptibility to landslides. This requires the identification of those areas that are, or could be affected by landslides, and the assessment of the probability of such landslides occurring within a specific period of time. Commenting on the time domain of landslide occurrence through zonation mapping is a difficult task. Due to conceptual and operational limitations, landslide hazard zonation is conceptually stated as Landslide Susceptibility Zonation (LSZ). The spatial prediction of landslides is termed as landslide susceptibility, which is a function of landslide and landslide related internal factors (i.e., ground characteristics). The aim is to identify places of landslide occurrence over a region on the basis of a set of physical parameters. LSZ can be formally defined as the division of the land surface into near-homogeneous zones and then ranking these according to the degree of actual or potential hazard due to landslides. The LSZ maps do not directly incorporate the time and magnitude of landslide occurrences. Since LSZ is conceptually accepted as LHZ, it is popularly referred to as LHZ all over India.

A landslide risk zonation map integrates the landslide hazard, vulnerability, and a quantification of the elements at risk. It cannot be developed unless an LHZ map is prepared. An important input for the preparation of an LHZ map is a landslide inventory database, which is not yet available in India. Thus, a landslide hazard assessment broadly involves the preparation of a landslide inventory, a landslide hazard zonation map, followed by a landslide risk zonation map

TO DO – The Government of Goa needs to prepare the Landslide Hazard Zonation (LHZ) Map of Goa detailing areas and zones that are prone to landslides. As well a Landslide Risk Zonation map of Goa needs to be prepared (This task can be assigned with the Geological Society of India)

Predictability

Frequency of occurrence, extent and consequences of landslides may be estimated and areas of high risk determined by use of information on area geology, geomorphology, hydrology and climatology and vegetation.

3.4.4 Factors Contributing to Vulnerability

- Settlements built on steep slopes, softer soils, and cliff tops
- Settlements built at the base of steep slopes, on mouths of streams from mountain valleys
- Roads, Communication lines in mountain areas
- Buildings with weak foundations
- Buried pipelines, Brittle pipes
- Lack of understanding of landslide hazards

The costs of slope failures will escalate as a consequence of developmental pressures unless active steps are taken towards mitigation and much more positive measures of hazard management are employed. There are several reasons for this in the state of Goa:

1. Economic and technological development has resulted in massive investment in infrastructure, buildings and industry, combined with increasingly complex patterns of commercial activity, all of which indicate growing vulnerability to landslide hazard. For example: - The widening of various stretches of the National Highway, has to take into consideration the risk of landslides as a result of this activity.
2. Developmental pressures have resulted in the opening and approval of hundreds of mining leases in the underdeveloped regions of Sanguem and Quepem, thereby increasing the possibility of landslides.

3.4.4 History of Landslides in Goa

Table 3.4.1 History of Landslides in Goa

S. No	Taluka	Location	Severity
1.	Tiswadi	Aradi, St. Cruz	Low
2.	Bardez	Nerul	Low
3.	Bardez	Malim, Betim	Low
4.	Bardez	Gaunswada, Mapusa	Low
5.	Bardez	Alto Betim, Mapusa (Panaji NH-17 near Mandovi Bridge)	High
6.	Pernem	Vaidongar	Low

The landslides specified at 1 to 4 and 6 were of low severity. In these cases, some boulders had slid towards residential structures / school buildings and caused severe damage to these structures. The landslide that took place at Mapusa-Panaji NH-17 during the monsoon of 2007 was severe as the vehicular traffic on this road was blocked for almost a month.

3.4.5 Impact Assessment of Landslide for Goa

Typical Adverse Effects

- Physical Damage – Anything in the path of a landslide will suffer damage. Rubble may block roads, lines of communication or water ways. Indirect effect may include loss of productivity of agricultural or forestlands, flooding, reduced property value.
- Casualties – Fatalities can occur due to slope failures, catastrophic debris slide or mud flows.

Impact Assessment Tools

- Damage Assessment Forms
- Population at Risk (Number of Citizens, Geographic location, Financial status, etc)
- Buildings at Risk – Categories in three different segments based on structure types (wood, concrete), functionality (residential, commercial, industrial and public)
- Livestock, crop area, industries (the location and exposure to which kind of disaster)
- Civil facilities: hospitals, health centers, educational institutes, warehouses, banks, police stations, fire stations, etc
- Infrastructure: Roads, bridges, culverts, ports, airports, railways, dams, telecommunication networks, power supply, water reservoirs & supply etc

3.5 Mining

3.5.1 Introduction

Goa is located along mid west coast of India. It covers an area of 3700 Sq. km. Goa is divided into two districts viz North Goa and South Goa which are divided into 11 talukas. The State of Goa is rich in minerals such as Iron ore, Manganese ore and Bauxite. Mining is an important economic activity and a significant foreign exchange earner for the State. Certain natural factors like the presence of a Coast Line, a good natural harbour and navigable perennial rivers have promoted the economic exploitation of these mineral deposits.
Mandovi and Zuari Rivers, their tributaries and the Cumbarjua canal are key factors in maintaining economic viability of Goan Mines. Transport of ore by barges is the cheapest option as compared to road and rail transport.

Table 3.5.1 : List of Mining Leases in Goa

Taluka	Area (Ha.)	No. of Mining leases existing
Bardez	240.41	04
Bicholim	3987.173	**057**
Pernem	179.775	002
Ponda	205.506	003
Quepem	2744.20	**025**
Sanguem	14214.3573	**208**
Sattari	2659.178	**035**
Total	24200.6	344

3.5.2 Export of Mineral Ores from the State of Goa

The mining of iron ore is the predominant economic activity in Goa. Other minerals mined in Goa are manganese ore, bauxite and moulding sand. Although the grade of the iron ore mined is not very high, the operation becomes economical because of the infrastructure of river transport in barges, the automatic mechanical loading facilities at the ports berth no 9 and the augmentation of the port

capacity through a unique system of midstream loading through trans-shipper vessels that help augment and optimize port capacity utilization and augment its capacity to load large vessels that draw a far higher draft than the 14.5 meters that the port normally handles at berth. The iron ore exports make the Mandovi and Zuari river connected by the Cumburjao canal the most navigated waterways in the Country with a cost effective fleet of about 300 barges.

In the past iron ore exports were mainly to Japan, and to a lesser extent, to European ports. Prices of iron ore had remained constant from 1972 to 2000 with cyclical fluctuations depending on the cycles of world steel demand and price. However, the opening of iron ore exports into China in a significant way in 2001 has made India into China's most economical iron ore exporter due to its proximity and consequent lower freight. Goa's exports have increased from 16 million tones in 2000 to 45 million tones today though its share of total Indian exports have dropped from 55% to 35%. Also due to Chinese imports, lower grades ores of up to 52% Fe grade which were previously treated as rejections are now exported. Additionally, import of higher Fe grade ores from Karnataka, mainly the Hospet region, have been blended with lower Fe rejects at Goa to maximize Goa's export tonnage.

The increased world demand for iron ore and the consequent rise in prices has also added to the Goan GSDP which is currently experiencing a boom. Goan Iron ore reserves are, however, limited and although the lower grade ore exports and higher prices which make deeper ore reserves more exploitable, have maintained the future life of iron ore exports from Goa at a constant 20 years, despite higher export tonnages, there is no doubt that after the estimated finite period the state of Goa will need to plan to replace this industrial activity which employs a large number of its people and sustains at least a third of its total population.

Table 3.5.2 – Exports of Mineral Ores from Goa

Type of Ore	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Goan Iron Ore	22,095,993	23,308,033	25,537,924	30,893,953	33,434,429	38,075,223
Non-Goan Iron Ore	8,442,447	9,237,207	10,733,726	9,642,721	6,117,626	7,513,548
Total Exports (Iron Ore)	**30,724,640**	**32,588,171**	**36,271,650**	**40,536,674**	**39,552,055**	**45,588,771**
Manganese Ore Groups	49,050	19,786	-	-	-	-
Bauxite	-	-	-	-	127,403	341,190
Goa Iron Ore Production	23,727,937	21,705,667	25,440,925	30,738,191	31,327,805	32,720,536

Source – Goa Mineral Ore Exporters' Association (2009)

3.5.3 Mining Related Disaster Profile for the State of Goa

Mining Belt of Goa

The mining belt of Goa, an area of approximately 700 Sq.kms. is mostly concentrated in four talukas namely Bicholim, Sattari, Sanguem and Quepem. The mining belt is divided into three regions based on the concentration of iron ore : the Northern zone, the Central zone and the Southern zone.

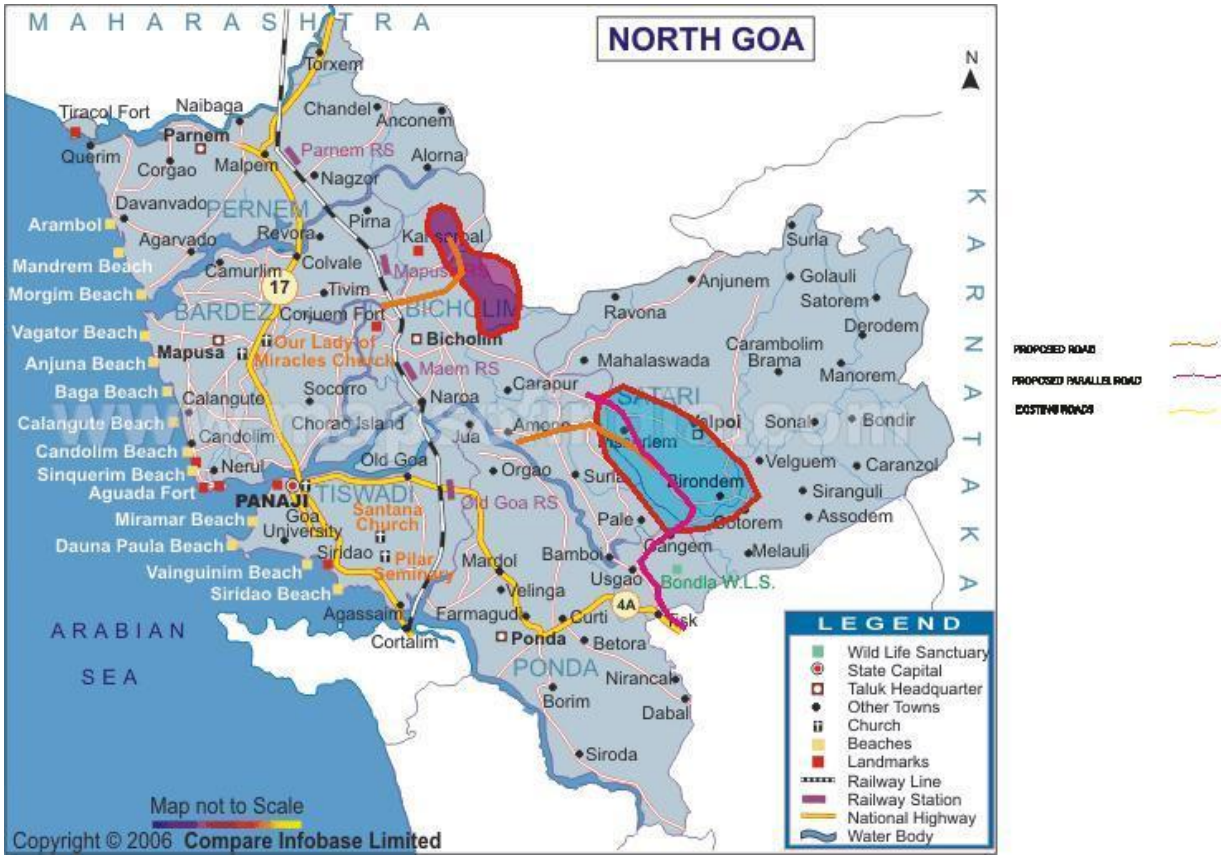


Figure 3.5.1: Northern Zone

Figure 3.5.2: Central Zone

Figure 3.5.3: Southern Zone

3.5.4 Disaster Risks in Goa due to Mining

Risks due to Mining Operations

- **Slope Failures** – During Monsoons and otherwise, there is a medium to high risk of slope failures.

  Severity – Low to Medium

  Frequency – If not managed properly, the frequency of slope failures in Open cast mines can be quite high. The frequency is also dependent on the soil composition.

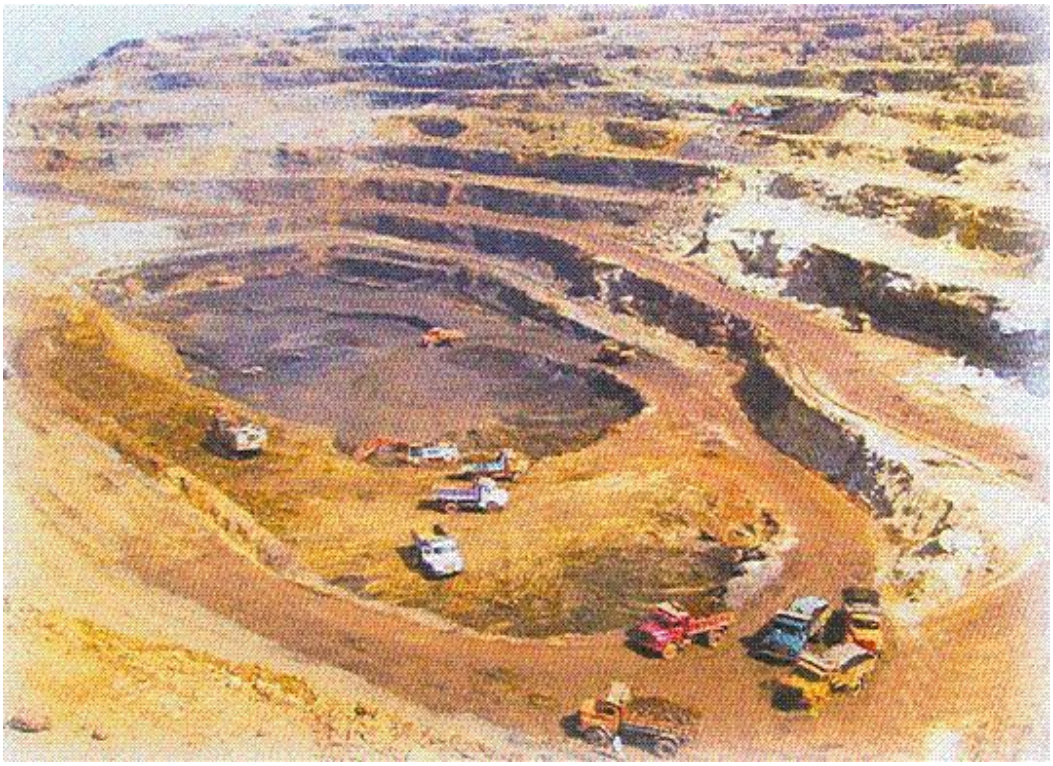


Figure 3.5.4

- **Dump Management** –

  Risks

  1. Runoffs from Dumps,
  2. Collapsing of Dumps and ,
  3. Siltation of River during Monsoons

  Severity – Low to Medium

  Frequency – Very High

Figure 3.5.5 – Dump Slope Failure and Runoff

Figure3.5.6 – Mining Reject Dump

- **Accidents during mining operations** – There can be minor to major accidents that can occur during mining operations. These are mainly due to human error, or other man-machine failures.

- **Environmental and Ecological Risks**
  The Energy Research Institute (TERI) was entrusted with a study by the Government of Goa in the year 1997 to identify and analyze the impact of mining on the environment and devise strategies to mitigate the adverse environmental effects. The report revealed that mining activities had resulted in a degraded environment.

- **Air Quality** – Air quality is affected in mines and surrounding villages due to high concentration of suspended particulate matter (SPM). The main reason for high SPM are fugitive dust caused by the movement of vehicles in opencast mines, mine roads and public roads, fugitive dust from dry screening plants, and fugitive dust from loading stations on the river banks (Government of Goa, DPSE, 2005).
  Severity – Very High
  Frequency – Daily, 24 Hours a day for 8 months in a year

- **Water Quality** – Waste water and runoff from dumps containing both dissolved and suspended solids pollute the rivers, streams, and nallahs throughout the year and is the dominant pollution source of surface water. These arise from the discharge into the river of both dissolved and suspended solids in untreated or partially treated mine water and beneficiation plant discharge water. In addition, runoffs from dumps result in siltation of river/nallah stretches and agricultural lands.
  Severity – High. Slow and gradual risk to health due to Suspended Paticulate Matter in the air surrounding the mining areas.
  Frequency – Daily, 24 Hours a day for 8 months in a year. During the Monsoons, the mining operations in Goa are halted.

- **Solid Waste Dumps** – Since the ore to overburden ratio ranges from 1:2.5 to 1:3 for Goan mines, large quantities of waste material is generated per tonne of iron ore mined.(Government of Goa, DPSE, 2005) Solid waste dumps (over burden and sub-grade ore) associated with mining are concentrated in the mining villages, which occupy large land surfaces and also pits, roads, beneficiation plants and tailings pond occupy large tracts of land.

- **Collapsing of Dumps –**
- **S**everity **–** High
  Frequency – The Occurrence of Dump failures is of a low frequency

- **Mining in Forest areas and near Sanctuaries** – Most mining leases are located in and around sanctuaries and forest areas. As a result there is complete incompatibility of uses. In recent years there has been a growing realization of the great value of forest areas, both environmental and economic (with new species of plants being discovered constantly and the potential to harvest this for the drug industry).[9]
  Severity – Very High. Can cause long term damage to the ecosystem. Destruction of bio-diversity due to deforestation.
  Frequency – All Mines close to the Forest areas have the potential to destroy the surrounding Bio-Diversity and Eco-System if proper steps are not taken.

- **Ground Water Depletion and Destruction of Farms and Livelihood** –
  According to the Regional Plan for Goa 2021, Agriculture has been severely affected in the area due to extraction of staggering quantities of ground water, vast areas being covered by siltation and mining dust, thus destroying farms and livelihood.[10]

  Severity – High

  Frequency – All mines dig below the water table and pump out this water. This results in depletion of Ground Water and in-turn impacts agriculture.

3.5.5 Impact Assessment of Disasters Related to Mining in Goa

Population at Risk (Number of Citizens, Geographic location, Financial status, etc)
The mining belt of Goa, an area of approximately 700 Sq.kms. is mostly concentrated in four talukas namely Bicholim, Sattari, Sanguem and Quepem.
All the population in these four talukas is prone to degradation of Air, and water quality.

Buildings at Risk – Categories in three different segments based on structure types (wood, concrete), functionality (residential, commercial, industrial and public)

The houses in villages in and around the mining areas concentrated in the four talukas of Bicholim, Sattari, Sanguem and Quepem are at risk due to collapse of mining dumps.

Livestock, crop area, industries (the location and exposure to which kind of disaster)

The agriculture and livelihood based on agriculture and related activities are at risk due to ecological degradation, and depletion of ground water. Further, the biological diversity in forest areas is at risk due to mining operations.

Infrastructure: Roads, bridges, culverts, ports, airports, railways, dams, telecommunication networks, power supply, water reservoirs & supply etc

Infrastructure such as Roads, Bridges, water reservoirs and supply are at risk in the four talukas of Bicholim, Sattari, Sanguem, and Quepem due to excessive road transportation of ore, and depletion of ground water.

3.6 Earthquake

3.6.1 Introduction

Definition of Earthquakes

When rock strata are subjected to stress, they begin to deform or bend. All rocks have a certain rupture strength, which means that they will continue to bend, rather than break, as long as the stress imposed on them does not exceed this rupture strength. When the stress finally becomes too great, the rocks suddenly move along a plane (the fault that may or may not have existed before the deformation began. That sudden movement snaps the rocks on each side of the fault back into their original shape and produces an earthquake.

Earthquake Zonation and Tectonic Maps of India

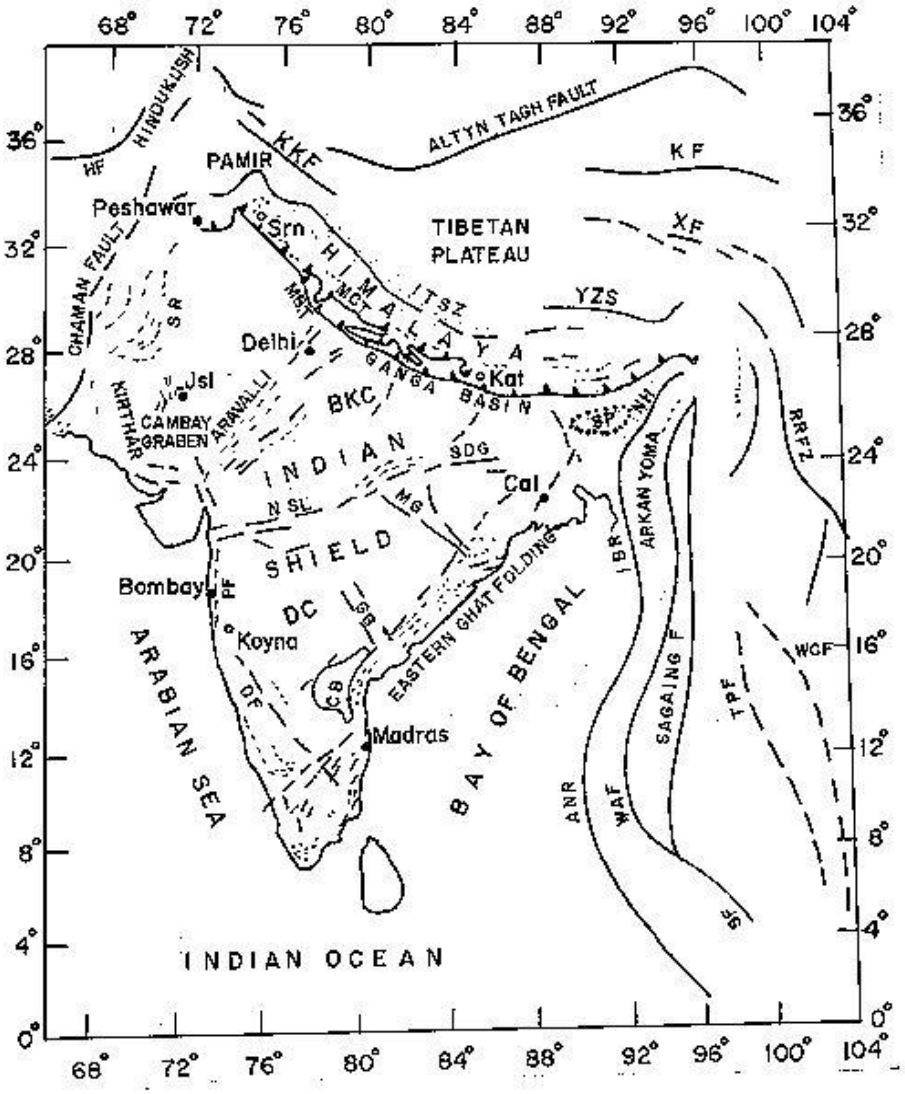


Figure 3.6.1 – Generalised Tectonic Map of India

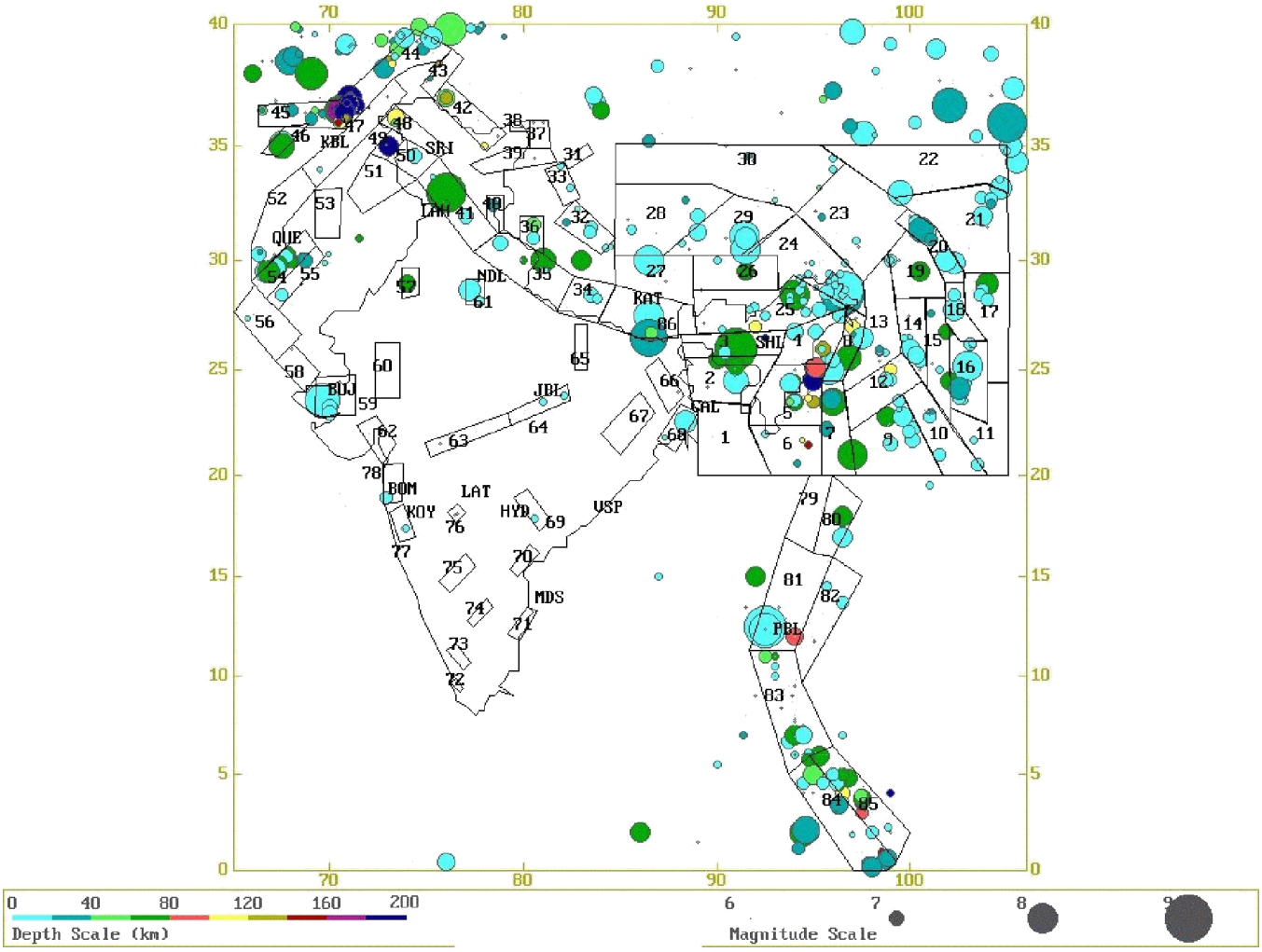


Figure3.6.2: Map of India with Earthquakes of more than 6 magnitude

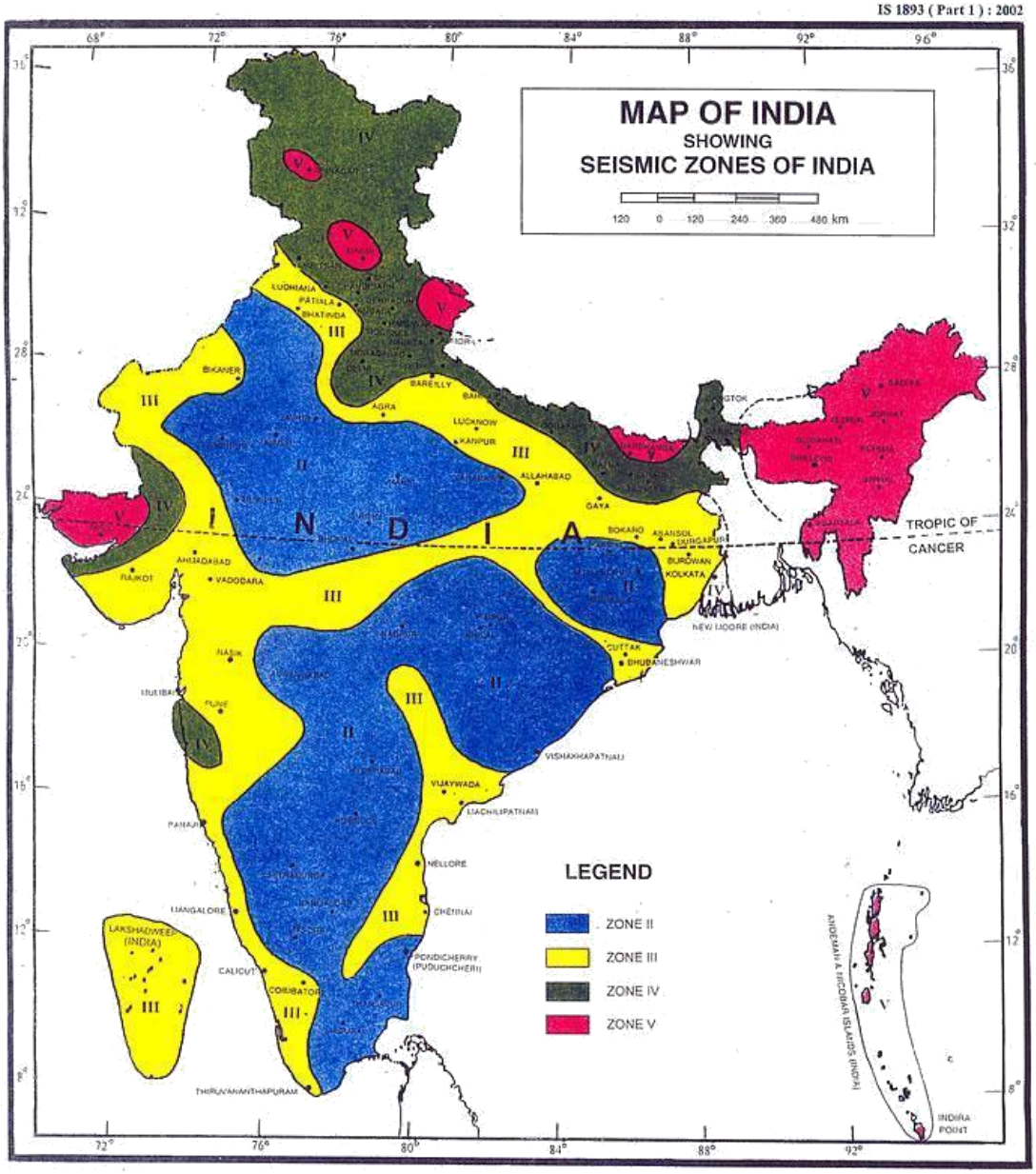


Figure 3.6.3 : Siesmic Zonation Map of India

3.6.2 Goa and its Geological make-up

Goa is in Zone IV of the Earthquake Hazard Zones of India. This means that there is a moderately high risk of Goa being struck by an Earthquake.

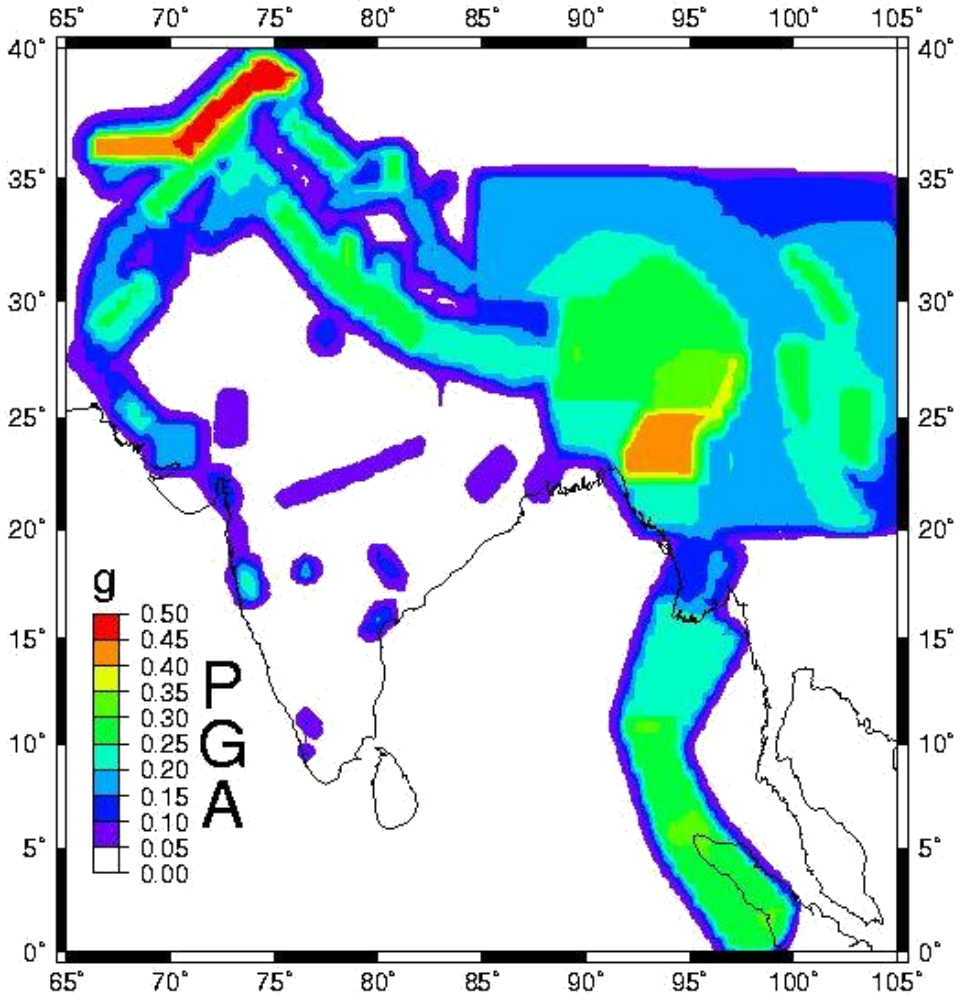
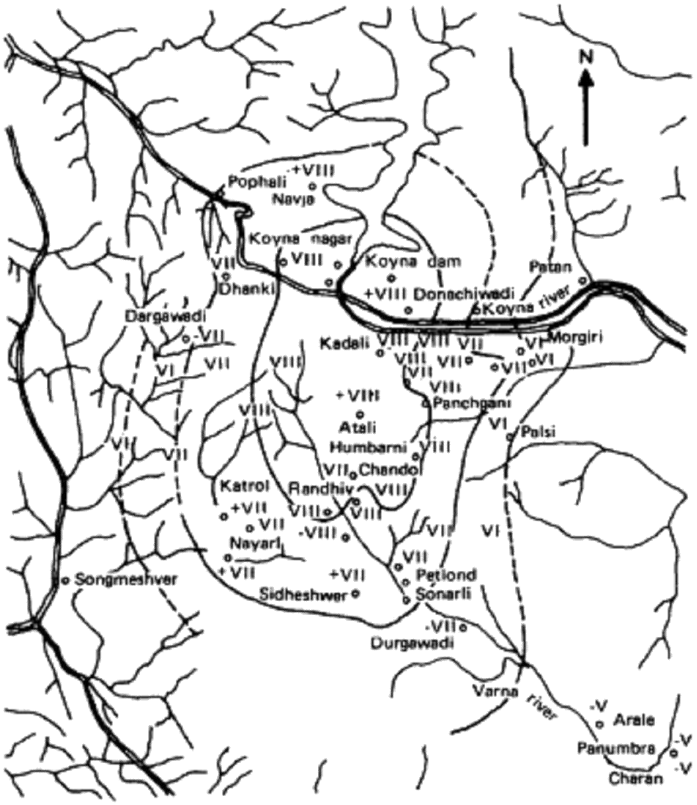


Figure 3.6.4: Siesmic Hazard Map of India

Table 3.6.1 Major Earthquakes in the Indian Sub Continent

Date	Location	Magnitude / Intensity	Fatalities	GSI Publication
16.06.1819	Kachchh, Gujarat	7.8 / X or XI	2,000	Mem. 47, 1926
10.01.1869	Cachar, Assam	7.5 / - VIII	-	Mem. 19, 1883
30.05.1885	Kashmir Valley, J & K	7.0 / X	3,000	Record 18, 1885
12.06.1897	Shillong , Meghalaya, Assam	8.7 / XI	1,500	Mem. 29, 1899
04.04.1905	Kangra district, Himachal Pradesh	8.0 / XI	20,000	Mem. 38, 1910
08.07.1918	Srimangal, Assam	7.6 / X	-	Record 46, 1926
02.07.1930	Dhubri, Assam	7.1 /	-	Mem. 65, 1934
01.02.1929	North Himalayan	7.1 / VIII (RF)	-	Record 62, 1929
27.08.1931	Mach	- / VIII (RF)	120	Mem. 67, 1934
15.01.1934	North Bihar-Nepal border	8.3 / X	10,700^	Mem. 73, 1939
30.05.1935	Quetta, Pakistan	7.5 / -	30,000	-
20.11.1937	Hindukush, Afghanistan	7.2 (Milne's) / VIII	-	Record 73, 1938
21.11.1939	Great Pamir, Afghanistan	6.9 / VIII	-	Record 75, 1940
26.06.1941	Andaman Islands	8.1 / -	-	Record 82, 1952
23.10.1943	Assam	7.2	-	-
15.08.1950	Arunachal Pradesh-China border	8.0 / X	1,526	Ind. Min. Vol. IV, No. 4, 1950
21.07.1956	Anjar, Kachchh, Gujarat	7.0 / IX	115	Unpub. R., 1956
10.12.1967	Koyna, Maharashtra	6.3 / IX	177	Unpub. R., 1968
19.01.1975	Kinnaur, Himachal Pradesh	7.0 / X	42	Unpub. R., 1975
21.08.1988	North Bihar-Nepal border	6.6 / IX	1,000	Sp.Pub.31, 1993
20.10.1991	Uttarkashi, Uttarakhand	6.6 / IX	978	Sp.Pub.30, 1992
30.09.1993	Latur, Maharashtra	6.3 / IX	7,446	Sp.Pub.37, 1996
22.05.1997	Jabalpur, Madhya Pradesh	6.0 / VIII	38	Sp.Pub.51, 2000
20.03.1999	Chamoli, Uttarakhand	6.8 / VIII	106	Bull. B53, 2001
26.01.2001	Kachchh, Gujarat	7.6 / X	13,805	Sp.Pub.76, 2003
26.12.2004	Andaman-Sumatra Sea	9.3 / -	10,500*	Sp.Pub.89, 2007
08.10.2005	Pakistan-India	7.6 / X	86,000**	Unpub.R., 2006
11.08.2009	North Andaman Sea	7.6 / -	Nil	-



Isoseismal map (showing intensities during 1967 Koyna earthquake of M = 6.5)

Figure 3.6.5 – Isosiesman map of the 1967 Koyna earthquake

The impact and tremors resulting from the 1967 Koyna Earthquake was felt in Goa. Due to this earthquake the region of Goa has been upgraded from Zone III to Zone IV Earthquake Zone of India.

3.6.4 Earthquake Impact Assessment for Goa

Goa is in the Siesmic Zone IV of India. The different Effects of an Earthquake are mentioned below:

Ground effects

Earthquake induced ground failure has been observed in the form of ground rupture along the fault zone, land slides, settlement and soil liquefaction as briefly described below:

Ground rupture: Ground rupture along the fault zone may be none, of -very small extent, or may extend over hundreds of kilometres. Ground displacement along the fault may be horizontal? vertical or both, and may be a few centimetres or metres. Obviously a building directly traversed by such a rupture will be severely damaged or collapse.

Liquefaction settlements: If the foundation soil consists of uniform loose sands within a depth of about 8 m. below the ground surface and is either saturated by or submerged under water, it may behave like a fluid when shaken by a strong earthquake (M M VIII or more). The buildings resting on such ground may sink or tilt and crack or collapse.

Land slides: Land slides are caused by earthquakes where the hill slopes are unstable due to badly fractured rocks or consist of loose material.

Rock falls: Many times rock falls also occur when precariously supported rock pieces or boulders are shaken loose and roll down the hill slopes.

3.6.5 Seismic sea waves (Tsunamis)

A Seismic sea wave or 'tsunami' is produced by a sudden movement of land mass during an earthquake with its focus on shore or off-shore under the sea. As the wave approaches the land, its velocity decreases but its height increases to 6 m. or even 9 m. Obviously, tsunamis can be devastating to buildings built in coastal areas.

3.6.6 Effects on buildings

Mechanism:

Buildings as a whole and all their components and contents are badly shaken during severe earthquakes by the ground motion referred to in section 2.6. Since earthquakes are earth movements (which, in effect cause the ground to move from under a building), the forces which occur in the buildings come from the inertia of its masses. Inertia force caused on any mass (m) can be described by the formula F = ma where a = acceleration effectively acting on mass m.

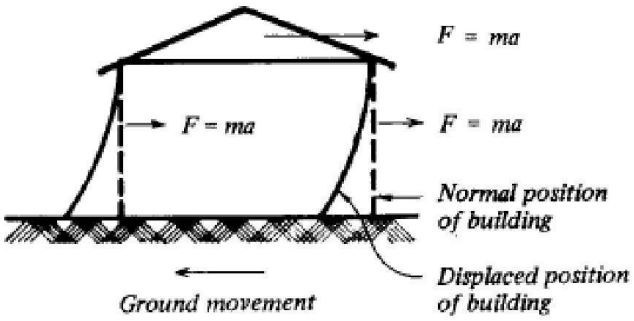


Figure 3.6.6 : Ground Motion Inertia Force

The force is proportional to mass. Hence the less the mass, the less is the inertia force caused by the earthquake on the building.

Building damage

The types of damage to buildings seen to occur during earthquakes are listed below.

Roofs:

- Falling of parapets, cornices, chimneys, cantilever balconies
- Displacement and falling of roofing tiles, cracking of asbestos cement sheet roofing, side coverings and ceilings

- Dislocation of roof trusses, wooden logs or joists and other roof beams from the walls and where the dislocations: are large, their collapse
- Collapse of heavy roofs due to the inability of the supporting structure to carry applied horizontal forces

Walls:

- Falling of plaster from ceiling and walls
- Fine or wide cracks in walls
- Horizontal and vertical cracks in walls due to bending of wall normal to its plane
- Gaps in walls due to collapse of portions of the walls
- Overturning of boundary walls, free standing partitions
- Diagonal cracking of wall piers between window and door openings, shearing of columns
- Shattering of random rubble masonry walls, falling of inner and outer withes (layers) of the wall away from each other
- Fall out of infix walls, cladding walls, and gable ends

Damage caused by foundation failure:

- Sinking, tilting and clacking or collapse of buildings due to foundation soil failure
- Spreading of individual column footings in soft soils

General damage:

- Partial collapse of building
- Complete collapse of free standing staircases
- Collapse of old wooden frames due to deterioration of joints
- Torsional failure of unsymmetrical buildings

History of Earth quake in Goa

There is no history of occurrence of earth quake in Goa.

3.7 Chemical Disaster

3.7.1 Sources of Chemical Disasters[11]

Nature of Chemical accidents :

Chemical accidents differ from other accidents and natural disasters such as floods, earthquakes, cyclones etc. in several respects. Some of the significant areas of differences include:

- Chemical accidents are sudden in their occurrence and do not normally give much warning of their occurrence.
- The progress of chemical accidents is generally fast. The effects of the accidents therefore spread very rapidly.
- Products of chemical accidents are transported into the environment through air water and soil routes affecting life systems and the environment.
- Protection against these chemicals can often be very complex on the scale in which the chemical accidents can manifest themselves.

Chemical accidents may originate in:

i) Manufacturing and formulation installations including during commissioning and process operations; maintenance and disposal.
ii) Material handling and storage in manufacturing facilities, and isolated storages; warehouses and godowns including tank farms in ports and docks and fuel depots.
iii) Transportation (road, rail, air, water, and pipelines)[12].

Causative Factors Leading to Chemical Disasters

Chemical disasters, in general, may result from:
i) Fire.
ii) Explosion.
iii) Toxic release.
iv) Poisoning.
v) Combinations of the above.

Chemical disasters may occur due to process deviations concerning the chemistry of the process, pressure, temperature and other identified parameters with regard to the state of the substance i.e., solid, liquid or gas, proximity to other toxic substances and the probability of a runaway reaction due to the incidental mixing of two or more HAZCHEMs with dissimilar properties.

In addition, it may be due to hardware failure, resulting in large-scale spills of toxic substances (in any form) due to loss of containment, or an explosion. Further, Boiling Liquid Expanding Vapour Explosion (BLEVE) may occur due to sparks, shocks or frictional forces on the chemicals during transportation. The effects can be further compounded by the micro-meteorology of the area, wind speed and direction, rate of precipitation, toxicity/quantity of chemical released, population in the reach of release, probability of formation of lethal mixtures (fuel-air or other mixtures) and other industrial activities being performed in closer vicinity. It is very important to understand that the state of the chemical substance (solid, liquid or gas) contributes substantially to the gravity of the accident and affects control measures. Chemicals in solid form may have devastating effects if their properties are suddenly changed (e.g., sublimation) due to pressure and temperature conditions to which they are accidentally exposed. If solids continue to remain in solid form, the damage will be negligible.

Any human/mechanical failure may cause large scale spills of liquids or of compressed gases like chlorine or Liquid Petroleum Gas (LPG) which can cause BLEVE and can directly affect human lives

and the environment. The release of compressed gases give rise to thermal and cryogenic stresses, which may also impact the surrounding structure or building, compounding the damage.

Although Goa has not faced any major natural disaster, there is all possibility of Goa being hit by cyclone, Goa also comes in Zone IV of the Earthquake area and flooding is also one more major area that Goa can face. These natural disasters have a huge potential to trigger a chemical disaster. Damage to phosphoric acid sludge containment during the Orissa super cyclone in 1999 and the release of acrylonitrile of Kandala Port, during an earthquake in 2001, are some of the recent examples.

Vulnerability to chemical disasters is further compounded by likely terrorist and warfare activities, which include sabotage and attack (including terrorist) on HAZCHEM installations and transportation vehicles.

3.7.2 History of Occurrence of Chemical Disasters:

In Goa till date no Major Chemical Accident has been reported to the Inspectorate of Factories and Boilers from the MAH units. Though Goa has not witnessed any major chemical disaster / accident in the recent past, there are several cases of major chemical accidents in India. The most devastating chemical disaster was the Bhopal Gas Disaster in 1984, other major incidences of chemical disasters in India include a fire in an oil well in Andhra Pradesh (2003); a vapour cloud explosion in the Hindustan Petroleum Corporation Limited Refinery (HPCL), Vishakhapatnam (1997); and an explosion in the Indian Petrochemicals Corporation Limited (IPCL) Gas Cracker Complex, Nagothane, Maharashtra (1990) and more recently the oil tanker fire in Jaipur in 2010. From 2002-06 more then 20 major chemical accidents have been reported in MAH units in India.

In Goa however transport accidents are quite frequent, though no statistics were available with the Government of Goa to validate these claims. However there have been rare casualties that have occurred due to the accidents to the Hazchem vehicles, for instance an accident that occurred in 1992-93 wherein a Hazchem tanker carrying Chlorine met with an accident leading to a leakage of the toxic gas and a few residents passing that area including the fire fighting personnel had to be hospitalized. There has also been an instance where in a tanker fell into a field that was being cultivated and as a result of the leakage of the Chemical which was corrosive in nature the land became infertile for cultivation.

3.7.3 Manufacturing and Formulation Installations and Storage Units in the State that have been classified as Major Accident Hazard (MAH) Units.

Manufacturing and Formulation Installations & Storage Units Classified as MAH In North Goa :

The MAH units in North Goa are well dispersed in the district making emergency planning a distributed exercise See Table 3.7.2 and Table 3.7.4

The basic hazards posed by MAH units in North Goa are explosion and fire from storage and handling of LPG. There are five such units which are handling LPG in North Goa. While thermal radiation from fires in these terminals is unlikely to have serious impact Off- Site with sufficient time with the local

public to protect themselves from the radiant heat, explosion effects can travel significant distances off-site affecting public safety.

The storage of ethylene oxide and propylene oxide at Venus Ethoxyethers Private Limited is another significant area of concern from both fire and explosion and toxicity angles.

The main toxic hazards of concern present in North Goa are:
Chlorine Storages at the facilities of Syngenta India Limited and the various Water Works of Goa State located at Opa and Assanora.

There is also the possibility of products of combustion from the large number of toxic chemicals handled by Syngenta India Limited and other potential users that could become airborne and be transported off-site to affect the public.

Manufacturing and Formulation Installations & Storage Units Classified as MAH in South Goa :

In South Goa Right from the Marmagoa Harbour to Verna Industrial Estate it is a Hazardous Prone area. See Table 3.7.3 and Table 3.7.5
Most MAH units in the district present fire and explosion as the main hazard. These are present in the petroleum terminals belonging to IOC and HPCL located at Vasco and Zuari Indian Oil Tanking Limited Petroleum Terminal on the Plateau of Sancoale near to the Sancoale Industrial Estate. Thermal radiation from fires in these terminals is unlikely to have serious impact off- site with sufficient time with the local public to protect themselves from the radiant heat.
Fire at the terminals could however create significant problems on account of dense smoke in the area affecting the ambient air quality. Further run-off from the storage tank dyke area could affect the neighboring population and facilities within the MPT area depending upon the prevailing gradient. This could eventually reach the estuary and affect the quality of marine life.
Other Fire hazards in the area include the petroleum products storages of Zuari Agro Chemicals Limited. Simulation for thermal radiation arising from fires in these uints show that the effects would principally be confined to within the factory premises. Like in the case of oil terminals secondary effects could include run-off which could affect receptors off-site.
LPG is stored in bottling plants of BPCL at Verna Industrial Estate. The bullets at BPCL installation are placed under cover of earth thus reducing the risk of fire and explosion to a minimum.

The main source of toxic hazards of concern present in South Goa are posed by storage units as follows:
Storage of liquid ammonia by ZIL at the factory as well as in the MPT area.
Inventory of chlorine tonner containers at Saluli Water Treatment Plant and at the ZIL factory.
Storage of Phosphoric acid by ZIL in the MPT area.

Note**:** Both Liquid ammonia and chlorine tonne storage in containers will have consequence of off-site as they could get airborne in the event of loss of containment. This affect the neighbouring public and environment.

Phosphoric acid on the other hand is a stable liquid under normal conditions. It can affect neighbouring population as an irritant and corrosive material. It could also affect the marine environment in the event of finding its way into the estuary.

3.7.4 Transportation hazards in Goa

The only information available on the transportation of hazardous chemical in Goa until 2009 was in respect of the MAH units based on their usage pattern. The main products transported to/from these units included liquid chlorine, petroleum products in tankers, liquefied petroleum gases in bulk and in cylinders, ammonia and phosphoric acid and chemicals in loose and in bulk form. According to the Directorate of Transport the most common chemicals that are transported into Goa are tankers transporting LPG, Sulphuric Acid, Caustic Soda, Ammonia, Naphta, Chlorine, Sodium Sulphate, Bhromine Chloride, Aviation Petroleum.

Hazardous material also enters North Goa and South Goa by road for local consumption in the state as well as transit to neighboring states. No statistics or records are available indicating the nature and quantity of such material. In the absence of details of such material emergency planning has been done on a generic basis. Only from the year 2009 the Government of Goa has imposed a cess on Hazchem vehicles which has to be payed at the entry posts so there is a thorough check and details are maintained regarding the vehicles carrying Hazchem goods entering the state. However prior to 2009 no such details have been maintained.

The main reasons cited for vehicles carrying Hazchem materials meeting with accidents are the negligence of the driver and the poor design of roads which are too narrow to enable smooth flow of traffic.

The routes by which the Vehicle carrying Hazchem goods ply by are through the national and state highways of the talukas of Pernem, Bardez, Bicholim, Sattari, Tiswadi, Ponda, Marmagoa, Salcete, Qeupem and Canacona excluding the Taluka of Sanguem. The entry point for the Hazchem vehicles in the North is Patradevi and the entry point from the South is Via Karwar in Karnataka. The Heavy Vehicles are not allowed to ply over the Zuari Bridge so they have to pass via Cortalim, Raia and Loutoulim through the Ponda Taluka if they want to go to Syngenta in the North. The Highway that passes through the Ponda Taluka is very close to the residential areas and hence it was suggested that the government could build a parallele bridge to the existing one over the river Zuari so that the Hazchem vehicles do not have to go to the North via the Ponda Taluka. Another suggestion was that the communication along the Karmal Ghats which is the entry route for the hazchem vehicles in the south should be developed as if there is any accident of the Hazchem vehicles it becomes very difficult to communicate with the Emergency Services.

Pipeline Hazards

North Goa District has no pipelines transport of hazardous material.

However South Goa District has the following types of pipelines transport of material.

- The MPT area has liquid petroleum pipelines from the Jetty to IOC's Terminal. These pipelines extend from the IOC Terminal to HPCL Terminal to supply the latter5's requirements.
- ZIL has a dedicated pipeline from the MPT Jetty to their phosphoric acid and liquid ammonia storage facility installation located within the MPT area.

- In addition to above, Indian Molasses Company and Ganesh Benzoplast have pipeline provide in the MPT area for pumping their products.

Suggestions and Important Findings:

- The Offsite Emergency Plan which was developed in 2002 (North and South Goa District) needs to be updated.
- Core groups which are constituted in Goa for updating and testing of the Off- site emergency plan can be merged with the District Crisis Group of the two districts. The District Disaster Management Authority can have interactionms with the District Crisis Group for details about the chemical disaster scenario in Goa (including preparedness and response).
- Manpower for the Inspectorate of Factories and Boilers as well as the Goa State Pollution Control Board needs to be increased. Particularly the Inspectorate of Factories and Boilers requires dedicated Senior Inspectors having chemical engineering knowledge.
- An MAH cell needs to be constituted within the Inspectorate which maintains records and information with regard to MAH units as well as installations handling chemicals slightly below the threshold limits as those handled by MAH units.
- There should be proper communication facilities developed at the Karmal Ghats, the entry route for many Hazchem tankers from the south of Goa as a lot of diificulty was faced to inform the emergency services when accidents of hazchem carrying vehicles have occurred.
- The stretch from the Mormugao port to the Verna Industrial estate is a very a Hazardous Prone area and needs special emphasis on conducting community awareness programmes.
- In General also the MAH units along with Village Panchayats need to undertake Community Awareness specially that section of the population that a at a risk from a possible chemical disaster not only frrom a manufacturing/ storage unit but also from potential transport hazards of hazchem transporting vehicles.
- The Highway that passes through the Ponda Taluka is very close to the residential areas and hence it was suggested that the government could build a parallele bridge to the existing one over the river Zuari so that the Hazchem vehicles do not have to go to the North via the Ponda Taluka.
- Statistics need to be maintained on the Hazchem vehicles entering the State including the chemicals they transport and the frequency of their entry into the State.
- Statistics also need to be maintained on the number of Hazchem vehicles that have met with accidents, the nature and time of the accidents, casualties if any.
- Industrial Units holding quantities marginally lower than those specified for MAH units including Small and Medium Entrepreneurs(SMEs) will also be documented and will have to follow all the safety rules and requirements as that of the MAH units. The marginal quantities should be specified after a study by experts
- The Government of Goa has four huge cranes provided by the Ministry of Surface Transport, however the Government needs to have the appropriate technical staff to operate the cranes which are quite frequently required if there is an accident of a hazchem vehicle. Currently Goa Government is dependent on private crane owners.
- The Fire and Emergency Services personnel need to have adequate Personnel protection equipment (PPE) to tackle thermal and toxic releases. This PPE'S also need to be provided to the Police and EMRI 108 services.
- The Goa Sate Pollution Control Board (GSPCB) needs to better equipped interms of detection of gases and other pollutants. The GSPCB has to still send samples of air and water pollutants emanating from certain industries to be tested out of the country as they currently do not

have the facilities and it leads to the wastage of time.

- The current function of the GSPCB is that of an advisory body however it needs to play an important role of undertaking the process of decontamination in case of a chemical accident either due accidents arising from transport or of a manufacturing/ storage unit.

Table 3.7.2: FIRE AND EXPLOSION DAMAGE SCENARIOS FROM MAH INSTALLATIONS IN NORTH GOA

No	MAH unit/ Activity	Taluka	Population	Material	Quantity	Affliction Distance, m.	Potential Damage
1	Goa Glass Fibres Ltd., Colvale	Bardez	2,27,695	LPG	2*30 T	371	Offsite damage
2	Finolex Cables Limited (Unit II), Usgaon-Tisk	Ponda	1,49,441	LPG	2*47T	431	Offsite damage
3	Hindustan Petroleum Corpn. Ltd. (LPG Bottling) Plant, Kundaim	Ponda	1,49,441	LPG	3*150T	635	Offsite damage
4	Venus Ethoxyethers Private Ltd. Bicholim Industrial Estate	Bicholim	90,734	Ethylene Oxide	7.5 T	410	Offsite damage
5	Venus Ethoxylates Private Ltd. Bicholim	Bicholim	90,734	Propylene Oxide	7.5T	221	Offsite damage
6	Filpack India Private Limited, Pillerne Industrial Estate	Bardez	2,27,695	LPG	2*10 T	260	Offsite damage
7	Syngenta India Ltd. Santa Monica Plant, Corlim, Ihas	Tiswadi	1,60,091	TMA	7.5T		Offsite damage
8	Esteem Industries Pvt. Ltd, Pissurlem Industrial Estate	Sattari	58,613	Ethylene Oxide Propylene Oxide	7.5T 14T		Offsite damage

9	Omni Impex Pvt. Ltd. Pissurlem Indusrial Estate, Honda	Sattari	58,613	Ethylene Oxide	7.5T		Offsite damage
10	Road Tanker			LPG	18T	313	Offsite damage
11	Road Tanker			M.S.	12Kl	60	Offsite damage
12	Road Tanker			Ethylene Oxide	14T		Offsite damage
13	Road Tanker			Propylene Oxide	16T		Offsite damage

Source: Government of Goa (April 2002) North Goa District: Off site Emergency Plan, Overview of Hazards in North Goa.

Note1: This Table has been updated based on data provided by the Insoectorate of Factories and Boilers.

Note2: Offsite Damage could also take place due to run -off from site

Table 3.7..4: TOXIC RELEASE HAZARDS MAH UNITS/ ACTIVITIES IN NORTH GOA

No	MAH unit/ Activity	Taluka	Population	Material	Quantity	Affliction Parameters 3m/sec "D" X,m	Y,m.	T, min	Affliction Parameter 1m/sec "F" X,m	Y,m.	T, min	Remarks
1	Syngenta India Ltd, Corlim Ilhas	Tiswadi	1,60,091	Chlorine	910 kg	3,620	556	20	8,250	581	90	Chlorine Tonners
2	Opa Water Works, Usgaon-Tisk	Ponda	1,49,441	Chlorine	910 kg	3,620	556	20	8,250	581	90	Chlorine Tonners
3	Assanora Water Works, Assanora	Bardez	2,27,695	Chlorine	910 kg	3,620	556	20	8,250	581	90	Chlorine Tonners

Source: Government of Goa (April 2002) North Goa District: Off site Emergency Plan, Overview of Hazards in North Goa

Table 3.7..5: TOXIC RELEASE HAZARDS MAH UNITS/ ACTIVITIES IN SOUTH GOA

No	MAH unit/ Activity	Taluka	Population	Material	Quantity	Affliction Parameters 3m/sec "D"			Affliction Parameter 1m/sec "F"			Remarks
						X,m	Y,m.	T, min	X,m	Y,m.	T, min	
1	Zuari Industries Limited, MPT Vasco	Mormugao	1,44,949	Ammonia	5,000 Te	5,160	460	150	13,200	358	180	Atmospheric Storage
2	Zuari Industries Limited, Zuarinagar	Mormugao	1,44,949	Ammonia	2,800 Te	41,440	1,650	165	100,000	240	1140	Horton Sphere
4	ZIL, Mobile	Mormugao	1,44,949	Ammonia	10 Te	2,680	248	75	2,440	297	120	Road Tanker
	Zuari Industries Limited, Zuarinagar	Mormugao	1,44,949	Chlorine	910 kg	3,620	556	20	8,250	581	90	Chlorine Tonner
5	Salauli WTP, Salauli	Sanguem	64,080	Chlorine	910 kg	3,620	556	20	8,250	581	90	Chlorine Tonner

Source: Government of Goa (April 2002) South Goa District: Off site Emergency Plan, Overview of Hazards in South Goa

Table 3.7.3 FIRE AND EXPLOSION DAMAGE SCENARIOS FROM MAH INSTALLATIONS IN SOUTH GOA

	MAH unit/ Activity	Taluka	Population	Material	Quantity	Affliction Distance, m.	Potential Damage
1	Indian Oil Coporation, Vasco Terminal	Mormugao	1,44,949	MS	4,490T		On site damage
				HSD	19,200T	46	
				ATF	13,050T		
				SKO	3,380T		
				FO	10,925T		
2	Hindustan Petroleum Corporation Ltd, Vasco Terminal, MPT harbour	Mormugao	1,44,949	Furnace Oil	27,436KL		On site damage
				LDO	4,100 KL		
3	Bharat Petroleum Corporation, Verna Industrial Estate	Salcete	2,62,035	LPG	33T	371	On site damage
4	Meta Copper & Alloys Limited, Zuarinagar Goa	Mormugao	1,44,949	LPG	50T	440	On site damage
5	Zuari Indian Oil Tanking Limited , Oil Terminal at Sancoale	Mormugao	1,44,949	Naphta	20,600T	To be updated	
				MS	9,800T		
				HSD	18,300T		
				SKO	4,800T		
5	Zuari Industries Limited, Zuarinagar	Mormugao	1,44,949	Naphta	34,100KL	85	On site damage
				Furnace Oil	11,590KL	55	Onsite Damage
	Zuari Indian Oil Tanking Limited TO Zuari Industries Limited	Mormugao	1,44,949	Naphta Pipeline	50-60T		Offsite Damage

	Port TO Zuari Indian Oil Tanking Ltd.	Mormugao	1,44,949	Any of the product (SKO/ HSD/ MS/ Naphta)	2580 KL		Offsite Damage
6	Reliance Infrastructure Limited, Goa Power Station Zuarinagar	Mormugao	1,44,949	Naphta	1000T	30	On Site Damage
	Pentair Water India Pvt. Ltd., Verna Industrial Estate	Salcete	2,62,035	LPG	8.34T		On Site Damage
	Road Tanker			Motor Spirit	12 KL		Offsite Damage
	Road Tanker			LPG	18T		Offsite Damage
	Road Tanker			SKO	12KL		Offsite Damage
	Road Tanker			HSD	20KL		Offsite Damage
	Road Tanker			ATF	20KL		Offsite Damage

Source: Government of Goa (April 2002) South Goa District: Off site Emergency Plan, Overview of Hazards in South Goa

Note1: This Table has been updated based on data provided by the Insoectorate of Factories and Boilers.

Note2: Offsite Damage could also take place due to run -off from site

Chapter 4: Hazard risk assessment and vulnerability mapping

The risk assessment of hazards, namely flood, chemical, cyclone, radiological, earthquake, landslides, have been done in respective chapters. Maps have been put in places where it is available, it is suggested that maps available with Town and Country Planning Department to be referred for any kind of developmental or construction work, as they have areas marked for various activities and contour levels in their taluka level maps.

The vulnerability mapping for the state of Goa is in the table 4.1
Legend H – High probability of occurrence, M – Medium probability of occurrence, L – Low probability of occurrence.

Table 4.1:Goa: Vulnerability mapping for South Goa district

Population 2001 census	Taluka	Population2001	Area in Sq.Km.	Cyclone	Flood	Landslide &Mining	Earthquake	Chemical	Sea Erosion	Nuclear &Radiological
589095	Mormugao	1,44,949	109.13	H	L	L		H		
	Salcete	2,62,035	292.94	H	M	L		L		
	Quepem	74,034	318.25	L	L	H	L	-		
	Sanguem	64,080	836.82	L	L	H		L		
	Canacona	43,997	352.04	H	H	M		L		

Table 4.2 :Goa: Vulnerability mapping for North Goa district										
Population 2001 census	Taluka	Population2001	Area in Sq.Km.	Cyclone	Flood	Landslide &Mining	Earthquake	Chemical	Sea Erosion	Nuclear &Radiological
758,573	Pernem	71,999	251.69	H	L	L	L	L		
	Bardez	2,27,695	263.97	H	L	M		H		
	Tiswadi	1,60,091	213.57	H	L	L		H		
	Bicholim	90,734	238.8	L	H	H		H		
	Satari	58,613	489.46	L	L	H		L		
	Ponda	1,49,441	292.78	L	L	L		H		

4.1 Disaster Management Administrative mechanism for the state of Goa

The state disaster management responsibility primarily lies with the State Disaster Management Authority (SDMA), under SDMA there are District Disaster Management Authorities (DDMA) for each district. These authorities are responsible for implementing all the disaster management activities starting from projects aimed at preventing a disaster, overseeing response mechanisms and ensuring proper relief and rehabilitation.

Constituents of Sate Disaster Management Authority (SDMA)

4.3 Government of Goa has constituted Goa Disaster Management Authority which comprises of the following:

SL.No.	Members	Designation
1)	Chief Minister	Chairperson-Ex-Officio
2)	Chief Secretary	Member-Ex-Officio
3)	Secretary (Revenue)	Member
4)	Collector (North)	Member
5)	Collector (South)	Member
6)	Director of Fire & Emergency Services	Member
7)	Director of General Police	Member
8)	Principal Chief Engineer (P.W.D)	Member
9)	Chief Engineer (Water Resources)	Member
10)	Chief Engineer (Electricity)	Member

Constituents of District Disaster Management Authority

The Government in terms of Section 25 of The Disaster Management Act 2005 constituted District Disaster Management Authority comprising of the following:

4.4 For South Goa

SL.No.	Members	Designation
1)	Collector (South)	Chairperson-Ex-Officio
2)	Chairperson of the Zilla Panchayat South Goa	Co-Chairperson
3)	Additional Collector-II, South Goa	Chief Executive Officer/Ex-Officio Member
4)	Superintendent of Police (South)	Ex-Officio Member
5)	Medical Superintendent of Hospicio Hospital,	Ex-Officio Member
6)	Director of Panchayat, South Goa	Ex-Officio Member
7)	Director of Municipal Administration	Member

Table 4.5 For North Goa		
Sl No.	**Members**	**Designation**
1	Collector & District Magistrate (N)	Chairperson
2	Chairperson- Zilla Panchayat (N)	Co Chairperson
3	Additional Collector/ ADM(N)	Chief Executive Officer/ Member
4	Superintendent of Police (N)	Member
5	Director of Health Services	Member
6	Principal Engineer, PWD	Member
7	Director, Fire and Emergency Services	Member

4.2 Administrative setup for Chemical Disaster

In compliance with the requirement of The Emergency Planning, Preparedness and Response to Chemical Accident Rules (EPPRCA) notified in August 1996 **, the Government of Goa formed a State Crisis Group and a District Crisis Group as stated below, however given the small size of the state and the districts therein, the District Crisis Group also serves the purpose of the Local Crisis Group . It is suggested to be maintained in addition to the above structure.**

Table 4.6: COMPOSITION OF STATE CRISIS GROUP (SCG) IN GOA	
COMPOSITION	
Chief Secretary	Chairperson
Secretary (Labour)	Member Secretary
Secretary (Environment)	Member
Secretary (Health)	Member
Secretary (Industries)	Member
Secretary (Public Health Engineering)	Member
Chairman, State Pollution Control Board	Member
Secretary/Commissioner Transport	Member
Director, Industrial Safety/Chief Inspector of Factories	Member
Director Fire and Emergency Services	Member
Commissioner of Police	Member
Representative from Industry (1)	Member
Experts (Industrial Safety & Health: (4)	Member
+ to be nominated	Member+
Source: Government of Goa (April 2002), South Goa/North Goa District: Offsite Emergency Management Plan	

The State Crisis Group may co-opt any person whose assistance or advice is considered useful in performing any of its functions, to participate in the deliberation of any of its meetings.

The State Crisis Group shall meet at least once every three months to follow such procedure for transactions of business as it deems fit.

FUNCTIONS

The State Crisis Group shall be the apex body in the State to deal with major chemical accidents and shall to provide expert guidance for handling major chemical accidents. Without prejudice to the above function, the State Crisis Group shall:

- review all district off site plans in the State with a view to examine their adequacy with the Manufacture, Storage and Import of Hazardous Chemicals Rules and forward a report to the Central Crisis Group once in three months;
- assist the State Government in managing chemical accidents at a site.
- assist the State Government in planning, preparedness and mitigation of major chemical accidents at a site in the State;
- continuously monitor the post accident situation arising out of a major chemical accident in the State and forward the report to the Central Crisis Group;
- review the progress report submitted by the District Crisis Group;
- respond to queries addressed to it by the District Crisis Groups
- publish a list of experts and officials in the State who are concerned with the management of chemical accidents.

Table:4.7 COMPOSITION OF DISTRICT CRISIS GROUP (DCG) IN GOA

COMPOSITION	
District Collector	Chairperson
Inspector of Factories	Member Secretary
District Energy Officer	Member
Directorate of Fire and Emergency Services	Member
Director, Information and Publicity	Member
Controller of Explosives	Member
Chief, Civil Defence	Member
Trade Union Representative	Member+
Deputy Superintendent of Police	Member
District Health Officer/Chief Medical Officer	Member
Commissioner, Municipal Corporation	Member
Representative Dept. of Public Health Engineering	Member
Representative, State PCB	Member
District Agricultural Officer	Member
Experts (4)	Member+
Commissioner Transport	Member
Industry Representative (1)	Member+
Chairperson/ Member Secretary (LCG)	Member
+ To be nominated by the Chairperson	

Source: Government of Goa (April 2002), SouthGoa/North Goa District: Offsite Emergency Management Plan

The District Crisis Group shall meet at least once every forty-five days and send a report of the proceedings to the State Crisis Group.

FUNCTIONS

The District Crisis Group shall be the apex body in the district to deal with major chemical accidents and to provide expert guidance for handling-major chemical accidents. Without prejudice to the above function, the District Crisis Group shall:

- assist in the preparation of the district off-site emergency plan;
- review all the on-site emergency plans prepared by the occupiers of Major Accident Hazards installation for the preparation of the district off-site emergency plan;
- assist the district administration in the management of chemical accidents at a site lying within the district;
- continuously monitor every chemical accident;
- ensure continuous information flow from the district to the Centre and State Crisis Groups regarding accident situations and mitigation efforts;
- forward a report of any chemical accident within fifteen days of its occurrence to the State Crisis Group;
- conduct at least one full-scale mock-drill of a chemical accident at a site each year and forward a report of the strength and weakness of the plan to State Crisis Group.
- The District Crisis group could conduct population awareness campaigns and educate the population likely to be affected in a chemical accident about the remedies and existing preparedness in the area.

4.3 Red Alert mechanism

To take care of Manmade Hazards,like act of different forms of terrorism including Bomb Blast Govt. of Goa has revised its Red Alert Mechanism and the document is maintained with the appropriate authority.

5.0 Incidence Response System (IRS)

In line with the guide line given in National Disaster Management Guidelines—Incident Response System ,A publication of the National Disaster Management Authority, Government of India.ISBN: 978-93-80440-03-3 the State IRS is prepared and is presented in a separate volume.

5.1 Taking care of tourist during Disaster

Considering the impact of toruism on Goa's economy and presence of huge number of tourists,about 200000 at any point of time, special emphasis need to be given to take care of the tourists in case of any calamity. It is suggested that the Tourism Dept. shall make sure that the Registered tour operators and the major Hotels are aware of the IRS and the Flood and Cyclone shelters near the beaches. The life savers,who are engaged by the tourism dept. will be a great support in cases like Tsunami,Cyclone and Floods. These life savers shall be aware of the Cyclone

and Flood shelters so that necessary guidance may be given to the Tourists in case of such cases. These lifesavers may also be included in IRTs and be trained on IRS

Chapter 6: Mainstreaming Disaster management concerns into Development Plans/Programmes/Projects

Chapter 7: Partnership with other stakeholders

Chapter 8: Financial arrangements

Amended in December 2014

Chapter 6: Mainstreaming Disaster Management concerns with developmental plans/programmes/projects

Overview:

The process of development and the kind of development choices made sometimes creates disaster risks. A close analysis of the development process with its six aspects namely policy, strategy, programming, project/program cycle management, external relations and institutional capacity; clearly argues for the need of systematic and more conscious ways of integrating disaster risk reduction (DRR) into development process. Mainstreaming disaster risk reduction into development planning should be a priority concern for the Goa State Government.

- Mainstreaming risk reduction should result in appropriate measures being taken to reduce disaster risk and ensure that development plans and programmes do not create new forms of vulnerability.
- In continuation with the efforts to integrate disaster management into development planning especially for new projects that are under preparation stage, the Central Government has revised the formats for pre-approval from **EFC** (Expenditure Finance Committee) and for preparing the **DPR** (Detailed Project Report) to address disaster management concerns.

Checklist- EFC format: To ensure the implementation of key areas, a check list for EFC format and the responsible departments are as shown below:

Task	Activity	Responsibility
Mainstreaming disaster management into development planning	1. To ascertain whether project involve any creation/ modification of structural/ engineering assets	• Line Departments: o Irrigation o Power o Water supply o Directorate of Health Services o Roads and Buildings o Education o Health o Others • Department approving the project o Administratively o Financially o Technically • Urban Development authorities Village Panchayats and Local Bodies.
	2.To ascertain the possible risks, likelihood and impact from disasters due to the location of project sites	
	3. To ascertain whether probable risks have been prioritized and the mitigation measures being contemplated, both structural and non-structural measures	
	4.To ascertain whether the design and engineering of the structure has taken into consideration the National Building Code 2005, the appropriate BIS Codes, other applicable sources as per the type of the project and the NDMA guidelines (List of codes/guidelines for safety of building/structures from natural hazards**).**	
	5. To ascertain whether the cost of disaster treatment/mitigation measures been included in	

	the overall project cost	
	6. To ascertain whether the process of risk assessment has been done based on available information and secondary evidence	

Checklist- for preparing DPR: To ensure the implementation of key areas, a check list for DPR format and the responsible departments are as shown below:

Task	Activity	Responsibility
Mainstreaming disaster management into development planning	1.Impact Assessment of project (damage that can be caused to the project by natural disasters, design of the project that could accentuate the vulnerability of the area to disasters and / or lead to rise in damage / loss of lives, property, livelihood and surrounding environment), checklist for natural disaster impact assessment if given in **Annexure 1** 2. Risk assessment of project 3. Vulnerability assessment of project (Evaluation of site with regards to parameters such as probable maximum seismicity, probable maximum storm surge, probable maximum wind speed, probable maximum precipitation, probable maximum flood discharge and level, soil liquefaction proneness under probable earthquake intensities) 4.Complacence of o land use management o Building Code o Building use regulation o Directives and Legislation o Maintenance requirement	• Line Departments: o Irrigation o Power o Water supply o Directorate of Health Services o Roads and Buildings o Education o Health o Others • Department approving the project o Administratively o Financially o Technically • Urban Development authorities Village Panchayats and Local Bodies.
	Details about the location of the project, proneness of the project area to various hazards and analysis of impact on safety of the project.	
	Impact of the project on the environment and the surrounding population with respect to the type of the project and adoption of mitigation measures to reduce the impact of the same	

Residual Agenda:

The Goa state is prone to natural disasters such as coastal and river flooding, cyclones, landslides, and industrial (man-made) disasters. The state economy has a potential to meet with the threat and challenges posed by these disasters. Moderate disasters are being managed through state disaster relief fund and central norms for disaster assistance.

However, for major disasters like once in 100-200 years event, some specific arrangements are required to be done as under:

Task	**Activity**	**Responsibility**
Raising funds for major disasters	1. Raising funds through long term disaster bonds.	Revenue department Finance department
	2. Raising fund (grant/loan) through bilateral or multi-lateral funding agencies	

Chapter 7: Partnership with other stakeholders

Disaster Management is an inclusive field and requires contribution from all stakeholders in order to effectively manage the emergency situation. Coordination amongst various stakeholders hence becomes extremely important to achieve the desired results.

There are various agencies/organizations/departments and authorities that constitute a core network for implementing various disaster management related functions/activities. It also includes academic, scientific and technical organizations which have an important role to play in various facets of disaster management. There are stakeholders within the state identified with their individual responsibilities and elaborately given in Part IV (department wise standard operating procedure) and Part II (Incident response systems). A brief note on the role and activities of such functionaries and the existing system of coordination established by the Goa State Government with them is mentioned below.

National Disaster Management Authority (NDMA)

- The National Disaster Management Authority (NDMA), as the apex body in the Government of India, has the responsibility of laying down policies, plans and guidelines for DM and coordinating their enforcement and implementation for ensuring timely and effective response to disasters.
- The guidelines assist the central ministries, departments and states to formulate their respective plans. It also approves the National Disaster Management plan prepared by the National Executive Committee (NEC) and plans of the central ministries and departments.
- It takes such other measures as it may consider necessary, for the prevention of disasters, or mitigation, or preparedness and capacity building, for dealing with a threatening disaster situation or disaster.
- It also oversees the provision and application of funds for mitigation and preparedness measures. It has the power to authorize the departments or authorities concerned, to make emergency procurement of provisions or materials for rescue and relief in a threatening disaster situation or disaster. It also provides such support to other countries in times of disasters as may be determined by the central government.
- The Goa state keeps in touch with the NDMA for implementing various projects / schemes which are being funded through the Central Government. The State also appraises the NDMA about the action taken by the State Government regarding preparation of DM plans and implementation of guidelines issued by NDMA for various hazards from time to time.

National Institute of Disaster Management (NIDM)

- The NIDM, in partnership with other research institutions has capacity development as one of its major responsibilities, along with training, research, documentation and development of a National level information base. It networks with other knowledge-based institutions and function within the broad policies and guidelines laid down by the NDMA.

- It organizes training of trainers, DM officials and other stakeholders as per the training calendar finalized in consultation with the respective State Governments.

National Disaster Response Force (NDRF)

- For the purpose of specialized response to a threatening disaster situation or disasters/ emergencies both natural and man-made such as those of CBRN origin, the National Disaster Management Act has mandated the constitution of a National Disaster Response Force (NDRF).
- The general superintendence, direction and control of this force is vested in and exercised by the NDMA and the command and supervision of the Force is vested in an officer appointed by the Central Government as the Director General of Civil Defence and National Disaster Response Force. Presently, the NDRF comprises eight battalions and further expansion may be considered in due course. These battalions are positioned at different locations across the country.
- NDRF units maintains close liaison with the designated State Governments and are available to them in the event of any serious threatening disaster situation. While the handling of natural disasters rests with all the NDRF battalions, four battalions are equipped and trained to respond to situations arising out of CBRN emergencies.
- Training centres are also set up by respective paramilitary forces to train personnel from NDRF battalions of respective forces and also meets the training requirements of State/UT Disaster Response Forces. The NDRF units also impart basic training to all the stakeholders identified by the State Governments in their respective locations. In addition, the State Government also utilizes the services of the NDRF whenever required during emergency search/rescue and response.

Armed Forces

- Conceptually, the Armed Forces are called upon to assist the civil administration only when the situation is beyond the coping capability of the State Government. In practice, however, the Armed Forces form an important part of the Government's response capacity and are immediate responders in all serious disaster situations.
- On account of their vast potential to meet any adverse challenge, speed of operational response and the resources and capabilities at their disposal, the Armed Forces have historically played a major role in emergency support functions. These include communication, search and rescue operations, health and medical facilities, and transportation, especially in the immediate aftermath of a disaster. Airlift, heli-lift and movement of assistance to neighboring countries primarily fall within the expertise and domain of the Armed Forces.
- The Armed Forces also participates in imparting training to trainers and DM managers, especially in CBRN aspects, and training of paramedics. Goa being a coastal state is home to a naval base. At the State and District levels, the local representatives of the Armed Forces have been included in their executive committees to ensure closer coordination and cohesion in all aspects related to Disaster Management.

Airport Authority of India (AAI)

- Goa has one International Airport in Dabolim (Vasco). When disaster strikes, the airports are quickly overwhelmed with the tons of relief materials (like food, bottled water, medical supplies, cloths, tents, etc.) arriving from all over the world. This material is urgently needed to be in the field.
- In such cases, AAI should appoint senior officer at the airport for proper handling and distribution (which includes precise unloading, inventory, temporary storage, security and distribution of relief material) of relief material during disaster situation.
- The AAI shall prepare and provide a list of equipments required for handling the material to either Goa State DM Authority or Commissioner of Relief. The equipments will be procured and maintained through nearest Emergency Response Centre (ERC). Deputation of team of official along with necessary infrastructure at the airports will be made available by the Commissioner of Relief for necessary dispatch and accounting of relief material during emergency situation.

Konkan Railways

- Konkan Railway is about 741km long connecting the Konkan coast of India (between Mumbai and Mangalore), Western Ghats with the rest of India. Unlike in other countries where the role of Railways, in the event of a disaster, is restricted to clearing and restoring the traffic, in our country Indian Railways handles the rescue and relief operations. Railways are preferred mode of transport both for the movement of people and relief material in bulk, if accessible.
- Railways should have a provision for transportation of mass community and proper handling and distribution of relief material (through special trains, if required) in their disaster management plan.

Indian Meterological Department (IMD)

The role of IMD has already been discussed in previous chapters

- The meteorological department undertakes observations, communications, forecasting and weather services. IMD was also the first organization in India to have a message switching computer for supporting its global data exchange.
- In collaboration with the Indian Space Research Organization, the IMD also uses the Indian National Satellite System (INSAT) for weather monitoring of the Indian subcontinent, being the first weather bureau of a developing country to develop and maintain its own geostationary satellite system.
- During the cyclone and flood seasons, the Goa State Government keeps close contact with the IMD in Goa for weather related forecasts.
- Earthquakes occurring in the State which are of magnitude 3.0 and above on Richter scale are also reported by the IMD to the State Government immediately.

INCOIS

- Indian National Centre for Ocean Information Services (INCOIS) is a national agency of the Government of India, under Ministry of Earth Sciences. It provides the coastal and ocean information services, supporting developmental and operational sectors like

ports, fisheries, shipping, meteorology, environment, off shore and coastal zone management in addition to promoting advanced oceanographic research in the country.

- INCOIS generates and disseminates near real time information on Sea Surface Temperature (SST), chlorophyll. Potential Fishing Zones (PFZ) advisories, tracking of oil spills, forecast economical shipping routes, and upwelling zones along the Indian coast, utilizing both remotely sensed and conventionally observed data.
- The parameters envisaged for dissemination include wind, wave, current, mixed layer depth, heat budget and maps on coral reef, mangroves, shore line change and land use pattern. INCOIS thus, plays an important role in supporting the nation for sustainable development of the coastal and ocean sectors through ocean information services.
- INCOIS has already put in place an early warning system for Tsunami through which it alerts the coastal States whenever an undersea earthquake of higher magnitude capable of triggering a Tsunami is reported. NIO in Goa, works in close cooperation with INCOIS and the Goa state government for strengthening disaster preparedness.

State Disaster Response Force (SDRF)

- As per the provisions of the National Disaster Management Act, the States are being encouraged to create response capabilities from within their existing resources on similar pattern of NDRP.

State Fire & Emergency Services

- The Goa State Fire & emergency Services are crucial immediate responders during any disaster. They are the first responders (during the Golden Hour after a disaster) and hence play a vital role in saving lives and property immediately after a disaster.
- The Goa State Government has therefore paid apt attention in equipping and strengthening the capacities of the Fire Services in responding to various disasters. The State Government has provided fire & emergency equipment to Municipal Corporations, Municipalities and the Emergency Response Centres to respond immediately after a disaster.
- Continuous training is also being provided to the fire staff in using and maintaining the equipment. Several officers of the rank of Chief Fire Officer are also sent to training organized by NIDM and other institutes of the Central Government from time to time.

Media

- Reducing the losses of life and property caused by natural hazards is a compelling objective now receiving worldwide attention. It is now being increasingly believed that the knowledge and technology base potentially applicable to the mitigation of natural hazards has grown so dramatically that it would be possible, through a concerted cooperative effort, to save many lives land reduce human suffering, dislocation, and economic losses simply by better information, communication and awareness.
- Timely mass media communication about impending disasters can lead to appropriate individual land community action, which is the key to implementing effective prevention strategies including evacuation and survival of people. Such communications can educate, warn, inform, and empower people to take practical steps to protect themselves from natural hazards.

- The role of media, both print and electronic, in informing the people and the authorities during emergencies thus, becomes critical, especially the ways in which media can play a vital role in public awareness and preparedness through educating the public about disasters; warning of hazards; gathering and transmitting information about affected areas; alerting government officials, helping relief organizations and the public towards specific needs; and even in facilitating discussions about disaster preparedness and response. During any emergency, people seek up-to-date, reliable and detailed information.
- The Goa State Government has established an effective system of partnering with the media during emergency situations. At the State Emergency Operation Centre (SEOC), a special media cell has been created which is made fully operational during emergency situations. Both print and electronic media is regularly briefed at predetermined time intervals about the events as they occur and the prevailing situation on ground. The Goa State Government has also ensured-that the interaction with media is a two way process through which not only the State Government provides the information / updates to the media but the media too, through their own sources / resources draws the attention of the Government officials to the need and requirement of the affected people. This helps the State Government to control the flow of information and prevent rumors which could create a panic situation during the disasters. The Goa State Government also partners with the media during Information Education and Communication (IEC) campaigns carried out for creating awareness amongst general public towards the precautions to be taken for prevention and mitigation of various hazards/events. A similar set up is also active at the District Emergency Operation Centre (DEOC).
- Apart from coordination with the media during disasters, the Goa State Government regularly partners the print and electronic media to publish / broadcast safety messages during public events and gatherings.

Chapter 8: Financial arrangments

State Disaster Response Funds and State Disaster Mitigation Funds are proposed to be created at the Goa State Level as mandated by Section 48 of the DM Act. The disaster response funds at the State level would be used by the Goa SDMA towards meeting expenses for emergency response, relief, rehabilitation in accordance with the guidelines and norms laid down by the Government of India and the Goa State Government.

All the state Government Departments, Boards, Corporations, Panchayat Raj Institutions and Urban Local Bodies would prepare their DM plans including the financial projections to support these plans. The necessary financial allocations would be made as part of their annual budgetary allocations and ongoing programs and should be used for mitigation and preparedness measures. They will also identify mitigation projects and approach the appropriate funding agency for funding the projects in consultation with the SDMA. The guidelines issued by the NDMA for various disasters should be considered while preparing mitigation projects.

The Goa state government should also look at other options of new financial tools like catastrophe risk financing, risk insurance, micro-insurance etc. to compensate for massive losses on account of disasters.

Opportunities of CSR investments should also be explored and elaborated under this section by the SDMA for increasing Goa State's resilience. Detailed SOP of each department along with their role and responsibilities have been presented in Part-IV of SDMP.

Annexure – 1 Check list for natural disaster impact assessment

Name of the Project:
State:
District:
Project Estimate Rs. _____ (Lakhs)

1. **Sitting of the Project**
   1.1 Location of Project site
      - Latitude
      - Longitude
      - Height above mean sea level

   1.2 Earthquake zone (any known geological fault nearby may be listed)
   1.3 Flood proneness & vulnerability:
      - Past history of floods the area
      - Observed Highest flood level
      - Frequency of flooding
      - Depth of flooding
      - Duration of flooding
      - Damage/loss (maximum, average, potential)

   1.4 Cyclone Proneness & Vulnerability:
      - Frequency and Intensity
      - Wind speed zone - information on highest wind speed
      - Distance of site from sea coast
      - Record of past storm surge

   1.5 Landslide Proneness & Vulnerability:
      - Location of Hill slope vis-a-vis the project's location
      - Past history of landslides,
      - Possibility of mud flows/rock falls/snow avalanches etc.

   1.6 Tsunami proneness & Vulnerability:
      - Past history

   1.7 Existence of Dams or Barrages upstream
      - Distance from the project. Was dam breach effect considered on the project?
      - If so, have the dam break analyses been carried out? Has their impact on safety of the project been evaluated?

2. Natural/Type of Project

2.1 All the projects of the natural/type mentioned below are liable to damage by natural disasters and inadequacies of design or any of their components is likely to accentuate the vulnerability of the area to the disasters and/or lead to rise in damage/loss to lives, property, livelihood systems environment.

- Communications: towers, lines, building
- Transportation: Roads, Railways, Bridges, Tunnels
- Power: Power houses, sub stations, power lines
- Water Resources: 'Dams, barrages, appurtenant structures, river training structures, Canals
- Habitations: townships- planning from the point of view of safety against hazards
- Water supply and sanitation projects including water supply and sewer lines
- Ports & Harbors
- Building projects
- Any other

3. Hazards Risk to the Project

Have the following been evaluated:

- Probable maximum seismicity at site and site dependent seismic design parameters
- Probable Maximum storm surge
- Probable Maximum wind speed
- Probable Maximum precipitation
- Probable maximum flood discharge and level
- Probability of occurrence of floods, earthquakes, landslides, mud flows, avalanches, cyclones, tsunamis
- Soil liquefaction proneness under probable earthquake intensities

4. Mitigation/Reduction of Risk:

4.1 There are specific codes, manuals, guidelines etc. developed by Bureau of Indian Standards, NDMA and concerned organizations for sitting, design, construction and maintenance of various types of infrastructures.

4.2 Have the relevant BIS codes and guidelines been complied with?

4.3 Have adequate safeguards to meet the risks of natural hazards as evaluated at Para 3 above, been adopted?

5. Impact of the project on the Environment and the People

Has the impact of the environment and the people been studied with the respect to the following and what mitigation measures have been adopted? An illustrative but not exhaustive list of scenarios is given below:

5.1 The earthquakes and landslides may damage the pipelines to transport and storages to store harmful and inflammable materials and gases in the project area. Has any study been made to assess the danger to the environment and the people posed by those occurrences? And if so what measures have been proposed?

5.2 The railway lines and roads run across the drainage lines and if adequate waterways at appropriate locations are not provided, it may result in rise in water level and drainage congestion in up-stream areas. Has this aspect been studied and if so, what mitigation measures have been proposed?

5.3 Land-slides triggered by earthquakes as well as due to inherent instability of slopes accentuated by rains, may lead to blockage of drainage channels and accumulation of water up-stream. These blockages may collapse due to their inherent instability or aided by rains. Labourers, machines and explosives can also be used to remove blockage and reduce flooding upstream. These lead to sudden release of water and flooding and erosion in down-stream areas. It may be stated whether any study has been carried out in this regard and what mitigation measures have been proposed?

5.4 As all the projects involve acquisition of land and influx of large number of people in the area to take up construction activities, it may result in deforestation and soil erosion. Measures for prevention of deforestation and arresting soil erosion are required to be taken. It may be stated whether any study has been carried out in this regard and what mitigation measures have been proposed?

5.5 If the project involves storage of water, failure of any component may cause flooding and large scale damage to lives, property and infrastructure etc. Please state whether any study has been made and if there is a possibility thereof, what measures have been proposed to meet the eventuality?

[1] http://www.imdmumbai.gov.in/cycdisasters.htm#How%20to%20avoid%20the%20catastrophe?

[2] Disaster Management Plan West Bengal, 2008-09

[3] http://www.imd.gov.in/section/nhac/static/cyclone-history-as.htm

[4] http://www.scidev.net/en/agriculture-and-environment/tropical-cyclones-1/features/cyclones-in-the-indian-ocean-facts-and-figures.html

[5] http://saarc-sdmc.nic.in/index.asp

[6] Current Science, Vol.91,No.4, dated 25August 2006

[7] Report on 'Has M.V. River Princess trigerred erosion along the Candolim-Sinquerim beach, Goa?' by M.T. Babu, R MAnimurali, K Sudheesh, Antonio Mascarenhas and P Vethamony, NIO, Goa

[8] Times of India, Panaji, Goa, dated 25April 2010

[9] RPG – 2021, Draft Regional Plan Goa – 2021, Task Force for Regional Plan for Goa – 2021, Page 44-47

[10] ibid

[11] Government of India, National Disaster Management Authority (April 2007), National Disaster Management Guidelines Chemical disasters

[12] Government of India, National Disaster Management Authority (April 2007), National Disaster Management Guidelines Chemical disasters

[13] Government of India, National Disaster Management Authority (April 2007), National Disaster Management Guidelines Chemical disasters

[14] Government of India, National Disaster Management Authority (April 2007), National Disaster Management Guidelines Chemical disasters