Mitigation Strategies to be adopted for Hazards on Ports: Case Study of Gujarat

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Abstract

A hazard becomes disaster only when it causes loss of human life and damage to property. In order to reduce the impact of such events through mitigation efforts it is necessary to understand how such hazards become disaster. Ports are the backbone of the Indian economy and in this era of globalization act as gateways of foreign transactions. Ports are focal points of convergence for several contending and competing business interests namely, shipping lines, port authorities, individual terminal operators to freight forwarders, inland logistics agencies and shippers whose cargo is being transported. The objective of the work is to study the direct, indirect and secondary damages to ports due to natural disasters and to develop the mitigation strategies. The scope of the work is restricted to the major port of Kandla and minor ports of Porbandar and Navlakhi. Moreover the impacts of natural disaster like cyclone and earthquake is only taken into consideration for the study purpose. Economic loss in Japan after the Kobe earthquake was exclusively due the loss of business and diversion of the cargos handled on Kobe port. Data collection and analysis for the work reveals that when any port is hit by natural disaster, it is always followed by direct losses due to the structural failures and loss of cargos, indirect losses due to the non-functioning of the ports and secondary losses due to its impact on the economic growth and increase in the fiscal deficit. Developing countries like India had been 'reactive' in its approach towards disasters – with precious resources being spent on relief, rehabilitation and reconstruction efforts but after the Bhuj earthquake the focus has shifted to a balanced approach including pre-disaster aspects such as disaster prevention, mitigation and preparedness. Developing countries like India shall move away from relief-centric approach to a pro-active assault on vulnerabilities through risk management measures and capacity building of industrial personnel.

Key Words: Ports[1], Disaster[2], Mitigation[3]

Introduction

Disaster can be broadly classified into two types namely natural and manmade. Natural disaster includes flood, cyclone, draught, earthquake, flood, landslide, tsunami, whereas manmade disaster include accidents (airways and railways), epidemic, fire which occurs frequently around the globe. India is one of the most disaster prone countries, vulnerable to almost all natural and man-made disasters. About 85% area is vulnerable to one or multiple disasters and about 57% area is in high seismic zone including the capital of the country. These disasters have a devastating impact on human life, economy, environment and national and socio economic development. Recent disasters, The Orissa Cyclone 1999, The Gujarat Earthquake 2001and Tsunami 2004 are cases in point.

Disasters not only pose a major threat to buildings, but also to **lifelines**. Lifelines are those systems, such as power, dams, ports and others that are necessary for human life and urban function and with the help of which large rural and urban regions exist. The impact/damages due to disasters may be direct and indirect. Direct damages occur during or after the phenomenon that caused disaster whereas indirect damages are perceived after the phenomenon, for a time period that lasts from weeks to months.

With the kind of economic losses and developmental setbacks that the country has been suffering year after year, the development process needs to be sensitive towards disaster prevention and mitigation aspects. In order to reduce the impact of such events through mitigation efforts it is necessary to understand how such hazards become disaster. The extent of vulnerability of area, people and property to hazard or the probability of its occurrence defines extent of risk. Vulnerability analysis and risk assessment are therefore essential forerunners for evolving the appropriate preventive measures and mitigation strategies.

Physical vulnerability relates to the technical capacity of lifelines to resist the forces acting upon them during a hazard event. Disaster prevention involves engineering intervention in buildings and structures to make them strong enough to withstand the impact of natural hazard or to impose restrictions on land use so that the exposure of the society to the hazard situation is avoided or minimized.

Need

1. Lifelines are the arteries and veins for our economy. Proper and healthy functioning of these lifelines are utmost important for the urbanization of the state as well as country.
2. Ports are most vulnerable to the disasters either natural or man-made.

3. When disaster hits the coastal areas, it leads to the devastation of the on shore as well as off shore structures and generally accompanied with the casualty.
4. Damage to the ports results in secondary damages (due to non- functioning of ports) which may affect the community and industry at large.
5. Looking to the frequency and impact of disasters that hits the country, there is a need to develop clear cut strategies to mitigate the disasters to reduce the direct and indirect damages.

Objective

The objectives of the study are as follows

1. To study the impact (direct damages) on ports due to disasters.
2. To study the secondary damages/impact due to disasters.
3. To propose suitable mitigation strategies for ports.

SCOPE

The scope of the present research work is restricted to the following:

1. Emphasis isonly on the natural disasters only, especially cyclones and earthquake as occurrence of these disasters on ports is frequent.
2. Impact of disasters on ports can be studied in variety of directions like structural, economic, social and environmental within which the work is restricted to the study of the structural and economic effect.
3. Effect of cyclone 98 and earthquake 2001 is studied as a case on major port (Kandla) and minor ports of Porbandar and Navlakhi.

Research Question

Are the strategies adopted for the port structures for mitigating the effect of natural disasters sufficient?

Methodology and Data Collection

Objective	Tasks	Data collected	Data Source
To study the direct damages due to disasters on ports	1. Effect of cyclones on port structures 2. Economic losses due to cyclones 3. Effect of earthquakes on port structures 4. Economic losses due to earthquakes.	1. Cyclone 98 2. (Kandla, Porbandar and Navlakhi ports), 3. Earthquake 2001 (Kandla, Porbandar and Navlakhi ports).	Port authorities, GSDMA, GMB officials, IIMA, CEPT library, GSDMA, website.
To study indirect/secondary damages due to disasters	1. Effect of cyclones on business i.e. cargo handled. 2. Losses due to non-functioning of ports due to cyclones. 3. Effect of earthquake on business i.e. cargo handled. 4. Losses due to non-functioning of ports due to earthquake.	1. Cyclone 98 2. (Kandla, Porbandar and Navlakhi ports), 3. Earthquake 2001 (Kandla, Porbandar and Navlakhi ports).	Port authorities, GSDMA, GMB officials, IIMA, CEPT library, GSDMA, website.
To develop and propose suitable mitigation strategies	1. To generate public awareness and educate. 2. Maintain and publicize evacuation path 3. Engineering contribution in mitigation 4. Role of corporate sector 5. Risk transfer mechanism 6. To create a culture of prevention.	Analysis of the case.	Self-analysis.

Table – 1 below shows the impact of disaster on ports along with tangible and intangible losses whereas table - 2 depicts the economic losses due to various hazards in India with population affected.

Table – 1: Impact of Disaster on society

Consequences	Measure	Tangible losses	Intangible losses
Deaths	No. of people	Loss of economically active individuals	Social and psychological effect on the remaining community
Injuries	No. and injury severity	Medical treatment needs, temporary loss of economic activity by productive individuals	Social and psychological pain recovery
Physical Damage	Inventory of damaged elements by no. and damage level	Repair and replacement costs	Cultural losses
Emergency Operation	Volume of labour, workdays employed, equipment and resources.	Mobilization costs, investment in preparedness activities	Stress and overwork in relief participants
Disruption to Economy	No. of working days lost, volume of production lost.	Value of lost production	Opportunities, competition and reputation
Social Disruption	No. of displaced persons, homeless	Temporary housing, relief, economic production, community moral	Psychological and social contacts cohesion
Environmental Impact	Scale and severity.	Clean up costs, repair costs.	Consequences of poorer environment, health risks, risk of future disaster.

Table – 2: Population affected in various hazards in last 15 years

Year	People affected (Lakh)	Houses & Buildings damaged (No. Lakh)	Damage/Loss (Rs. in crore)
1985	595.6	24.5	40.06
1986	550.0	20.5	30.74
1987	483.4	29.19	20.57
1988	101.5	2.42	40.63
1989	30.1	7.82	20.41
1990	31.7	10.2	10.71
1991	342.7	11.9	10.90
1992	190.9	5.7	20.05
1993	262.4	15.3	50.80
1994	235.3	10.51	10.83
1995	543.5	20.08	40.73
1996	549.9	23.76	50.43
1997	443.8	11.01	N. A.
1998	521.7	15.63	0.72
1999	501.7	31.04	1020.97
2000	594.34	27.16	800.00
2001	780.19	8.46	12000

Data Analysis

Ports are a crucial part of the transportation infrastructure of the country. The international experience with economic development has emphasized the development that has taken place near the coast through “gains from trade”. Total export and import of cargo from or to the India is done by various modes of transportation, in which port sector has the major role in trade and commerce*(refer figure – 1)*. The foreign trade to be through the maritime route is 90% by volume and 70% by value*(figure – 2)*. Ports are classified as: Major ports (a list of named ports where the central government

plays policy and regulatory functions) and Non major ports (which are guided by state governments), which are further classified as intermediate ports and minor ports. India has **13 Major Ports and 187 Non Major Ports** along 7,517 km long Indian coastline. There is lot of traffic generated by trucks carrying the cargo on the road and wagons by rail tracks because of export and import of commodities from the Indian ports. Major ports are handling almost 75% of total cargo handled at all the ports of India and non-major ports are handling 25% of total cargo (*refer figure – 3*).

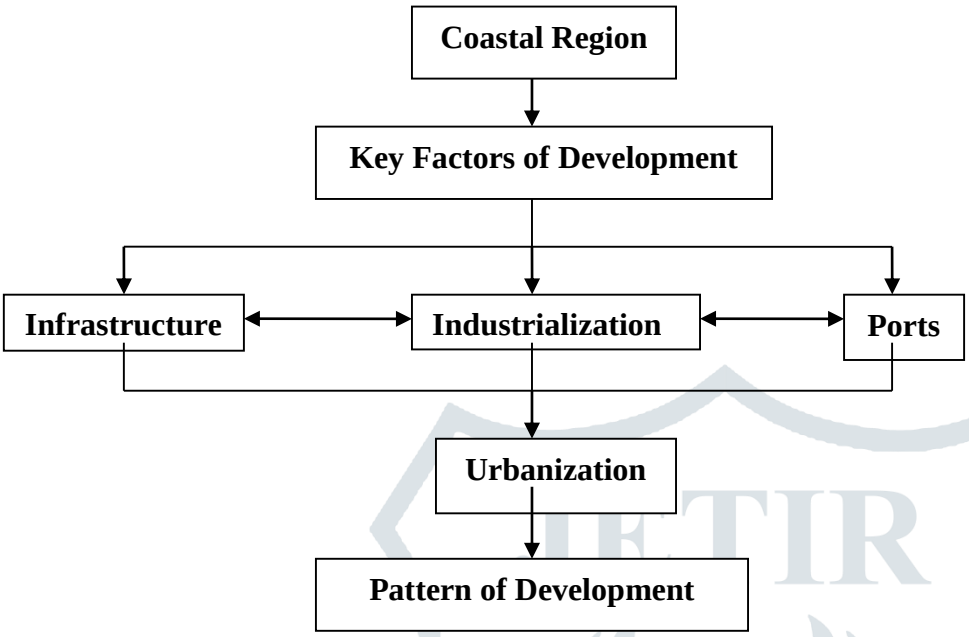

Figure – 1: Importance of Ports in development of Country

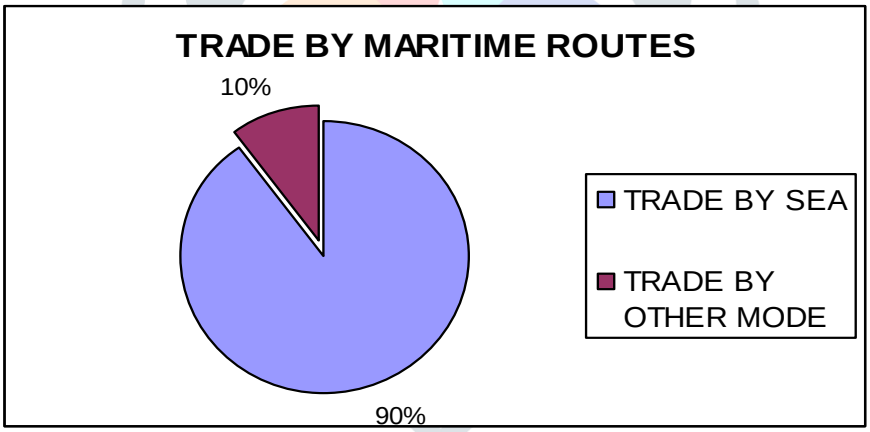

Figure -2: Business carried out by waterways (2005-2006)

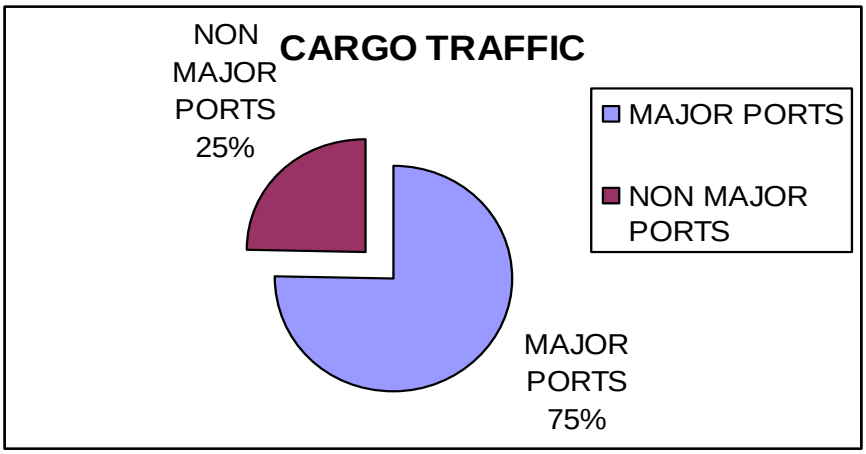

Figure - 3: Percentage Cargo handled by Major and Minor Ports (2005-2006)

The economic impact due to the disasters can be depicted well by studying the overall effect on society in terms of direct, indirect losses and secondary losses and particularly at ports by studying the statistics of the traffic handled by the ports hit by disasters*(table – 3)*.

Table - 3: Estimate of Asset losses and Reconstruction costs due to cyclone and earthquake

Sector	**Asset Losses ($ million)**		**Reconstruction Costs ($ million)**	
Disaster	**Cyclone 98**	**Earthquake 01**	**Cyclone '98**	**Earthquake '01**
Housing	9.116	1111	9.116	1107
Health	1.02	47	1.02	60
Education	0.044	144	0.044	180
Sub-total (Social Sectors)	10.18	1302	10.18	1347
Irrigation	1.487	40	1.487	90
Rural Water Supply	7.076	50	7.076	97
Municipal Infrastructure	0.053	30	0.053	45
Public buildings	18.94	73	18.94	95
Power	105.9	40	105.9	98
Transport	0.129	69	0.129	77
Ports	**62.86**	**21**	**62.86**	**26**
Telecommunication	18.09	11	18.09	26
Sub-total (Infrastructures)	214.6	334	214.6	554
Agriculture	77.12	117	77.12	74
Industry	61.15	73	61.15	44
Services	63.44	250	63.44	200
Sub-total (Productive Sectors)	201.7	440	201.7	318
Environment	1.086	55	1.086	55
Grand Total	**518.1**	**2131**	**518.1**	**9909**

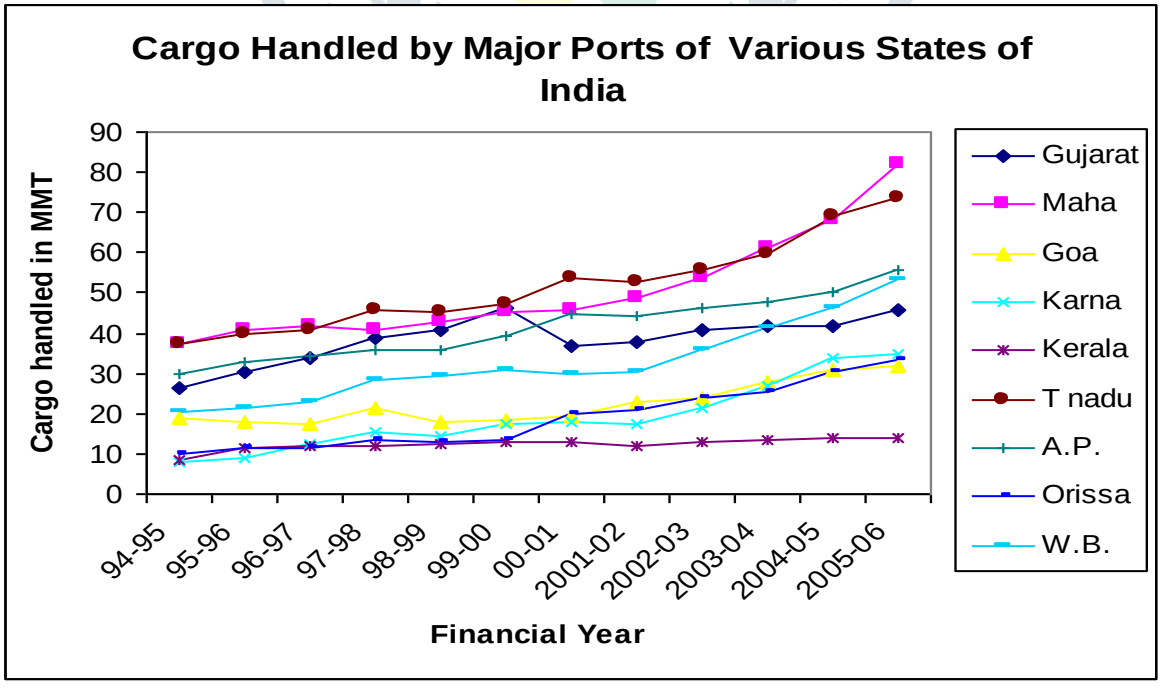

Figure - 4: Cargo handled by major ports of India

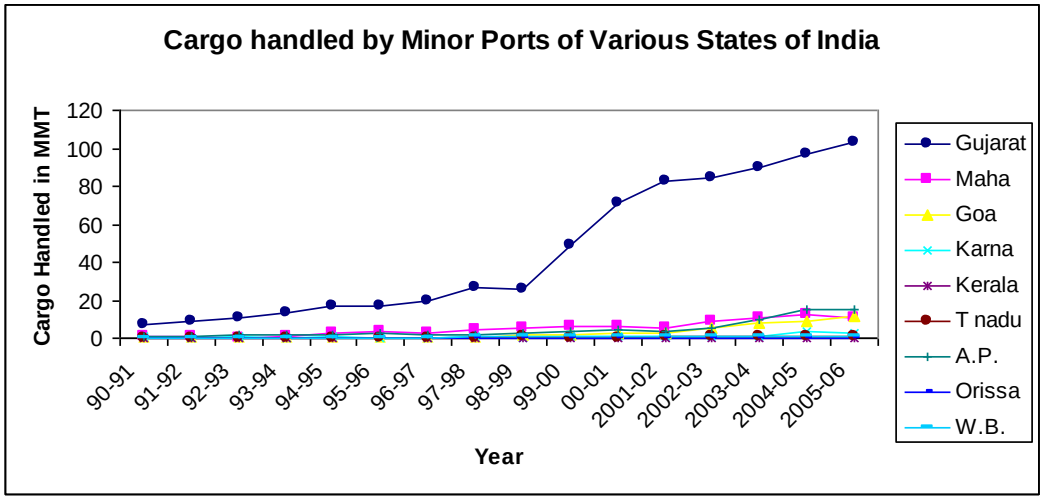

Figure – 5: Cargo handled by minor ports of India

Inferences

Following are the inferences from the data collected

1. Most of the port structures damaged during the cyclone and earthquake were old structures of 1950's.
2. Not designed as per relevant codal provisions.
3. Types of the soil existing in the vicinity of the ports are soft clay &silty clay which are prone to liquefaction.
4. Some of the structural failures were exclusively due to liquefaction.
5. Problem of soil structure interaction.
6. Warning systems not adequate and appropriate.
7. Referring the data of the cargo handled at the ports hit by disaster, it is evident that disasters have direct relations with the development of the ports.
8. Loss of business due to the disasters is considerable which is evident from the growth rate scenario of the ports.
9. Not only the business is affected, but the service sector is also affected considerably.
10. Disasters are always accompanied with the damages to the structures, loss to the infrastructural facilities which are the arteries and veins of our system, epidemics, and rehabilitation and restoration costs.
11. Mitigation strategies not adequate. Hence emphasis shall be laid on mitigating the disasters.

Mitigating a Disaster

1. *Improve Public Awareness*
   a) Educate the public about hazards prevalent to their area
   b) Publicize the documents associated with emergency response and mitigation
   c) Maintain and publicize a current action plan for emergency response.
   d) Maintain and publicize current evacuation routes

2. *Minimize the Impact of All Hazards*
   a) Development of strategies, land use plans and maintenance of emergency infrastructure

3. *Minimize the Impact of Natural Hazard Events on built structures*
   a) Improve the resistance of structures in the community against natural hazards
   b) Reduce the impact of Natural Hazard Events on trees near built structures.
   c) Decrease the potential for structural damage from wind event debris
   d) Decrease the potential for the loss of critical utilities during major storm events

4. *Improve the state's Technical Capability*
   a) Implement a GIS/GPS Setup for the state/town/area.
   b) Record all structures within the cyclone prone areas.
   c) Improve the area's capability to identify areas needing future mitigation

A summary of considerations to be made in the programming, identification and appraisal stages of a new construction or strengthening project for hazard-risk reduction can be obtained by *Creating a Culture of Prevention* and ensuring the following steps

Stage I: Define roles and responsibilities
Stage II: Hazard assessment
Stage III: Review of legislation and good practice
Stage IV: Review of construction methodologies and local Capacity
Stage V: Set hazard safety objectives
Stage VI: Site selection
Stage VII: Design and procurement
Stage VIII: Construction
Stage IX: Operation and maintenance
Stage X: Evaluation

A method of analysis for port structures based on performance is suggested below;

Type of Analysis	**Simplified analysis**	**Simplified dynamic analysis**	**Dynamic analysis**	
			Structural modeling	**Geotechnical modeling**
Gravity quay wall	Empirical/Pseudo-static methods with/without soil liquefaction	Newmark's type analysis simplified chart based on parametric studies	FEM/FDM linear or non-linear analysis 2D/3D	FEM/FDM linear (Equivalent linear) or non-linear analysis 2D/3D
Sheet pile quay wall				
Pile-supported wharf	Response spectrum method	Pushover and response spectrum methods		
Crane				
Cellular quay wall	Pseudo-static analysis	Newmark's type analysis		
Breakwater				

Table 4: Methods of Analysis for port structures

Conclusion

The rigorous study of the work, review of the literature on similar works, collection of the relevant data's and its analysis leads to the following conclusions;

1. Developing countries like India had been 'reactive' in its approach towards disasters – with precious resources being spent on relief, rehabilitation and reconstruction efforts but after the Bhuj earthquake the focus has shifted to a balanced approach including pre-disaster aspects such as disaster prevention, mitigation and preparedness.

2. Disaster is always followed by casualty, injuries, physical damage, and emergency operation, disruption to economy, social disruption and environmental impact and its effect may be short term or long term depending upon the area of concentration of the disaster.

3. Case study on the ports of Kandla, Porbandar and Navlakhi clearly indicates that as and when the disaster strikes the port, it leads to the major economic impact due to the damage to the structures (on shore and off shore), damage to the machineries, non-functioning of the ports, loss to the cargo, loss of business.

4. Sufficient care shall be taken during the planning stage, designing stage, implementation stage and construction stages of the port structures.

5. Ensuring that transportation, storage, handling and usage of chemicals and other hazardous raw materials does not pose a secondary threat to the nearby areas and environment in event of disaster.

6. Performance Based Design (PBD) shall be adopted for port structures.

7. Large-scale awareness generation initiatives aimed at building the knowledge, attitude and skills of the common people for a safer habitat.

8. New technologies like GIS, RS and GPS shall be used for mapping a hazard and formulating mitigation strategy.

9. It is also proposed to secure active participation of corporate sector in risk mapping of the area hosting the industry and in training and capacity building of the community in its disaster preparedness activities. It is also envisaged to create an industry-led voluntary force for search and rescue and first-aid etc.

10.Warning systems shall be properly designed and its effectiveness shall be checked at regular interval.

11.A group of Engineers (civil, mechanical & electrical), Doctors, Social workers, Machinery operators shall be given periodic training to work during and after disaster.

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