Report No. 26844-IN

India
Financing Rapid Onset Natural Disaster Losses in India:
A Risk Management Approach

August 2003

Document of the World Bank

UNITS AND ABBREVIATIONS

Currency Unit = Rupee (R)
Rs 1.00 = **US$.0204** (as taken in the study)
US$1.00 = Rs 49.0 (as taken in the study)
1 Crore = 10,000,000
1 **Lakh** = 100,000

Abbreviations and Acronyms

AAL	Average annual loss
ADB	Asian Development Bank
AEP	Aggregate exceedance probability
AHDR	Annualized hazards damage ratio
ART	Alternative risk transfer
CDF	Cumulative distribution function
CDMP	Comprehensive Disaster Management Program
CEA	California Earthquake Authority
CRF	Calamity Relief Fund
DANA	Damage assessment and needs analysis
ELT	Event loss table
EP	Exceedance probability
FEMA	US Federal Emergency Management Agency
FHCF	Florida Hurricane Catastrophe Fund
FRPCJUA	Florida Residential Property and Casualty Joint Underwriting Association
GDP	Gross domestic product
GEERP	Gujarat Earthquake Emergency Reconstruction Program
GoI	Government of India
GSDMA	Gujarat State Disaster Management Agency
GSDP	Gross state domestic product
HPC	High Powered Committee
IDA	International Development Association
IDB	Inter-American Development Bank
IDRC	Canadian International Development Research Center
IRDA	Insurance Regulatory and Development Authority
ISO	Insurance Service Office
LOB	Line of business
MDR	Mean damage ratio
MMI	Modified Mercalli intensity
MOA	Ministry of Agriculture
MOF	Ministry of Finance
NBER	US National Bureau of Economic Research
NCCF	National Calamity Contingency Fund
NCCM	National Center for Calamity Management
NCDC	National Climatic Data Center
NCDM	National Center for Disaster Management
NDMD	Natural Disaster Management Division
NFCR	National Fund for Calamity Relief
NGO	Non-governmental organization
OEP	Occurrence exceedance probability
OPD	Operations and Policy Department, World Bank

PGA	Peak ground acceleration
PMF	Probable maximum flood
PML	Probable maximum loss
PMP	Probable maximum precipitation
RMSI	Indian subsidiary of a global geographic information services company (RMS)
TCIP	The Turkish Catastrophe Insurance Pool
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
US$	US dollar equivalents
USAID	US Agency for International Development

Vice President:	**Mieko Nishimizu**
Country Director:	Michael Carter
Sector Director:	Joseph Pernia
Team Leader:	Rodney Lester

FOREWORD

Over the last 35 years of the 20th Century India suffered more then 150,000 fatalities as the result of rapid onset natural disasters. Formally reported direct property and infrastructure losses from natural disasters over the same period amounted to US$30 billion, but actual losses will have been substantially higher. An increasing frequency and severity of natural disasters poses a growing challenge to economic and social development and the country's fiscal balance. Thie resultant need to formally address the impact of naturel hazards is reinforced by the fact that the poor are almost invariably most affected by the occurence of calamities. In the last decade the situation has been exacerbated by the fact that most Indian states and the central government have been running deficits and resources for post disaster reconstruction in particular have become increasingly constrained.

Given this context and a clearly expressed concern on the part of the Indian authorities as fiscal pressures grow, the World Bank undertook a detailed review of India's catastrophe exposures, with in depth studies in four states. The purpose of the study was to examine the loss potentials from rapid onset natural disasters and to consider the opportunity to apply enhanced country and state level risk management techniques, with a particular emphasis on the financing of post disaster reconstruction and the efficient allocation of public funds.

The report is a product of two years of research to understand the natural catastrophe risks that India faces and the way they are currently managed and financed. It is the first time that there has been an attempt to develop a comprehensive catastrophe risk management framework that brings together risk financing and mitigation techniques and contains an in-depth discussion of the role of institutional incentives in national disaster management.

Signed: Marilou Uy, Director, Financial Sector, Operations and Policy Department

Marilou Uy Date: Oct 2, 2003

Acknowledgements

This study was funded by the South Asia Region with support from the Financial Sector Vice Presidency of the World Bank. Support for the study was also provided under the umbrella of the ProVention Consortium from the United Kingdom's Department for International Development (DFID). The team thanks DFID for their generous support.

The authors are Rodney Lester and Eugene Gurenko of the OPD Department of the Financial Sector Vice Presidency. Vijay Kalavakonda, also of OPD, provided operational support and contributed to the Appendixes and Chapter V. Other key members of the original mission team in February 2002 were Alcira Kreimer and Margaret Arnold from the Disaster Management Facility and Priya Basu and Santosh Kumar from the Indian Country Office. Torben Andersen provided background data for Chapter I and Mina Hamedani contributed her experience at Fannie Mae to Appendix V. Manisha Shah and Rick Zechter provided logistical support during the production of this document. The World Bank team working on the Bhuj (Gujarat) earthquake reconstruction effort has also provided valuable input. The authors would also like to acknowledge the professional contribution by RMSI, an Indian risk modeling consultancy, which was commissioned to carry out in-depth studies of catastrophe loss potentials in four selected states. In addition, we would like to thank all those Indian professionals who provided inputs on the Indian disaster response system and on the development of the Indian general (non-life) insurance sector.

Thanks is also due to all those who contributed so willingly to this project through interviews and feedback, including representatives of the Ministry of Finance, the members of the High Powered Committee on Disaster Management, IRDA, various state disaster management bodies, federal departments handling key infrastructure, and representatives of the insurance, reinsurance, risk management and finance sectors, and of other development organizations. We should also thank the World Bank country office staff and consultants who proved to be so helpful during our two visits, and the three external (Paul Freeman, Andrew Dlugolecki, Professor Arya) and two internal (John Pollner, Christoph Pusch) reviewers who helped to shape this paper. Chris Hoban's positive skepticism was key to developing a more nuanced and realistic view of the nature of the natural disasters funding gap.

TABLE OF CONTENTS

List Of Tables

LIST OF CHARTS

LIST OF FIGURES

Executive Summary

Background

Natural catastrophes pose a serious and growing threat to India's development. Twenty-two of India's 31 states are regarded as particularly prone to natural disasters: 55% of its land is vulnerable to earthquake, 8% is vulnerable to cyclone and 5% is vulnerable to flood. Munich Re. has ranked India's four megacities as amongst the 50 most vulnerable mega cities in the world. On average, direct natural disasters losses amount to up to 2% of India's GDP and up to 12% of central government revenues.[1] Despite being centred in a relatively underdeveloped area, the Gujarat earthquake is estimated to have caused a US$491-655 million loss of output, a US$2.2 billion negative impact over three years on the state's fiscal deficit[2] and led to a national 2% tax surcharge.

Total losses reported due to natural catastrophes have been growing. Reported direct losses from natural catastrophes more than quadrupled during the 15-year period 1981-1995 ($13.4 billion) compared to the losses registered during the previous 15 years ($2.9 billion). This alarming trend continues; the total losses of US$13.8 billion reported in the most recent six-year period (1996-2001) have already exceeded total losses incurred over the previous 15-year period.

Responsibility for disaster funding in the aftermath of a natural catastrophe has been shared by the state and central governments. While the affected state manages the relief work and reconstruction efforts, the central government provides financial support. Originally, the central government financed catastrophe relief efforts through margin money allocated to the states through the successive Finance Committees. However, the general experience under this system was that actual calamity expenditures consistently outpaced underlying budget expectations. Under the Ninth Finance Commission, the government revised the system and created a Calamity Relief Fund (CRF) from which states can draw upon under emergencies. The Eleventh Finance Commission limited the use of CRF funds to items which provide immediate relief to the affected population. This Commission also proposed an enhanced role for the insurance markets.

One limitation of the current formal disaster relief funding mechanisms involves the funding of the restoration of infrastructure. While states are required to maintain and restore infrastructure from planned capital budgets, these budgets have become increasingly constrained with a growing share of state budgets going to recurrent expenditures and debt service on burgeoning public sector deficits. Faced with dwindling capital budgets some states have resorted to diverted development loans to fund infrastructure repairs. These often involve intense renegotiation and ongoing rigorous procurement rules, although there have been efforts to expedite the process in India. As a result, in the absence of adequate and timely funding for capital repairs the expected future lives of some of the infrastructure assets are reduced post disaster, while future capital projects necessary to support a growing economy are not undertaken.

---

[1] Direct losses are stock losses (mainly infrastructure and housing). Indirect losses are flow items such as state revenues and GDP. Fiscal effects are sometimes called secondary losses.
[2] World Bank/ ADB Assessment Report

The growing problem of funding natural catastrophe losses has been recognized by the Finance Commissions; every Finance Commission since the Second has devoted a full chapter to calamity relief funding. Despiite these efforts, India continues to suffer from underdeveloped state level risk management capacity and underutilization of private insurance mechanisms.

The Study

In light of India's vulnerability to growing losses due to natural disasters and escalating fiscal pressures at the central and state levels, the World Bank undertook a detailed review of India's catastrophe exposures. The goal of this project was to examine loss potentials from rapid onset natural disasters and to consider the opportunity to apply enhanced country and state level risk management techniques, with a particular emphasis on the financing of post disaster reconstruction and the efficient allocation of public funds. The role of insurance markets has also been examined given their major contribution to the effective transfer of private sector catastrophe risk in other countries, but relatively insignificant role in India to date.

The country risk management approach developed by the World Bank is based partly on corporate risk management principles, but accounts for key economic and social metrics such as government fiscal profiles and the living conditions of the poor. The first step under this methodology is to assess the potential losses from natural hazards on a probabilistic basis, and detailed studies were carried out in four states. The next step involves a formal and structured approach to understanding the funding of natural calamity losses and identifying the "natural disasters funding gap," which is the difference between the expected fiscal cost of an event and available ex post sources of government revenue.

The World Bank team recognizes that enhancing implementation capacity and reducing asset vulnerability by employing mitigation techniques (such as improving housing construction standards) are also integral to reducing direct losses from natural catastrophes. The risk management framework ideally includes ex ante capacity building, risk reduction and methods to transfer or finance residual risk. In particular, in the course of the study it became clear that even if funds are accessible post disaster, they may not be availed because of a lack of capacity and capability. The funding gap concept has been modified appropriately.

The main body of the report is divided into five chapters. The first chapter explores the fiscal impact of historical natural disaster losses and the funding methods used by the satte and central governments to date. It demonstrates that the fiscal and economic pressures caused by these calamities are significant and justify a formal risk management approach. Chapter II introduces the formal risk management framework used in the report: the Country/State Risk Management Model. It also discusses various ex ante risk management and ex post coping strategies the various governments could adopt. Chapter III develops the risk management framework with an in-depth analysis of the natural catastrophe loss potentials in four states. Chapter IV is a detailed review of India's insurance market and examines various demand and supply drivers. It concludes that given current conditions, government intervention would be required in order to develop an effective natural catastrophe insurance market in India. The final chapter presents the team's findings, highlight policy options and make recommendations based on our findings. The five appendices highlight topics and present information related to the main document that will supplement the reader's knowledge.

Conclusions and Recommendations

The study concludes that India still adopts a primarily reactive, or coping, approach to dealing with natural disasters. Though considerable progress has been made via mitigation and disaster preparedness to reduce both financial and human losses, at the center and in some states, India's current approach to funding natural catastrophe losses remains fragmented. It lacks a comprehensive catastrophe risk management framework to quantify, analyze and manage potential losses. The current program, particularly at the national level, lacks institutional incentives and underplays the role of risk financing through ex ante mechanisms such as catastrophe reinsurance and contingent credit facilities. The development of ex ante funding programs is particularly critical because these programs typically serve as a primary source of immediate liquidity that would reduce human suffering, economic loss, and fiscal pressures in the aftermath of a natural disaster, and kick-start economic recovery. Ex ante funding approaches can also foster mitigation and provide incentives for institutional capacity building.

Based on the study, the World Bank team has identified several policy options and recommendations for the Government of India.

Policy Options:

- Mitigation and risk financing are the two pillars of effective catastrophe risk management at the country and state level, and GoI's mitigation efforts could be augmented by a formal approach to risk financing. A risk financing strategy would consist of three parts: formal risk assessments at the state and the central levels; identification of funding gaps; and finally, development of state and national risk management plans aimed at closing the identified funding gaps over time.
- Create fiscal incentives for states to pursue active risk management strategies, including building institutional capacity at the state level.
- The existing institutional framework for catastrophe risk management could be further developed in two ways. First, a Risk Financing Facility could be created to provide additional financial assistance to those states which are adopting and implementing an agreed risk management approach. Second, the use of contingent credit facilities could be explored for catastrophe risk financing and in support of risk management incentives at the state level. Sucha a contingent credit facility would become available to meet claims of the states in the aftermath of natural disasters, provided an acceptable state risk management program is in place.
- Introduce incentives and perhaps mandated requirements to increase the utilization of catastrophe insurance mechanisms by the private sector, including better off households. This could be done by requiring that replacement cost catastrophe insurance is purchased when mortgage financing is granted; tying catastrophe insurance to land tax or land registration systems; or making it clear, if necessary through regulation, that households in the upper and middle income brackets are not eligible for government reconstruction funding.[3]

[3] The World Bank team does not suggest that GoI should stop financing housing reconstruction in the aftermath of a disaster. We recommend that the government should adopt a clear policy of not helping those who can afford to help themselves by buying insurance (or through self-insurance). According to various surveys this group accounts for between 7% and 10% of the population. The poorer segments of population with substandard housing should continue to be entitled to government post disaster assistance.

Recommendations

While the options outlined above will require consideration within the larger Indian fiscal and sectoral policy framework, the scope for further reform in the insurance sector to add capacity and increase the penetration of disaster insurance is relatively clear. For this reason we have characterized the relevant policy steps as recommendations.

- The insurance sector should be further liberalized by removing current restrictions on, and cross subsidies from, the household and small business insurance markets.
- Claims handling procedures in the event of natural disasters should be streamlined and formalized.
- More explicit rules should be introduced regarding insurers' minimum premium retentions and maximum risk retentions, and exposure accumulation data should be gathered and reported to IRDA.

Progress and Challenges

The paper is a product of a two year study to understand the natural catastrophe risks that India faces. It is the first time that there has been an attempt to develop a comprehensive catastrophe risk management framework for India. Similarly the models developed for the four states are pioneering efforts. The main challenge that had to be faced in developing models to precisely assess the risk for India was the availability of accurate data. The models could have been built to a greater degree of detail to assess vulnerability more accurately, for example, by accounting for differences in house layouts and number of stories in houses, but relevant and reliable data was not available. Nonetheless, the team believes that both the models and the framework provide a firm basis for understanding India's exposure to natural catastrophes, the resultant funding gaps it faces, and for developing appropriate incentives to encourage active risk management.

Introduction

The Commonwealth Disasters Index, despite being developed to support a case for better off small states to access development funds, includes India in the 5 countries most vulnerable to natural disasters. Perhaps the most telling measure of India's exposure and vulnerability is the human death toll (defined as killed and missing people). Within the last five years of the 20th century alone, various natural catastrophes claimed more than 45,000 victims across South Asia with the majority of these fatalities occurring in India (Table 1).

Table 1: Reported Natural Catastrophe Impacts in South Asia, 1996-2000.

Country	Deaths (thousands)	People affected (thousands)	Country Population (thousands)	Event Densities	
				Deaths (per ten thousand)	Affected (percent)
India	28.8	247,480.0	1,029,991.1	0.28	24.0
Pakistan	2.2	5,128.7	144,616.6	0.15	3.5
Afghanistan	8.4	2,960.1	26,813.1	3.11	11.0
Bangladesh	2.7	30,036.3	131,269.9	0.21	22.9
Sri Lanka		1,595.6	19,408.6	0.02	8.2
Bhutan	0.2	1.0	2,049.4	0.98	0.0
Nepal	4.3	297.4	25,284.5	1.71	1.2
	46.7	287,498.9	1,379,433.2	0.92	10.1

Sources: Swiss Re, Natural catastrophes and man-made disasters 1996-2000; CRED, International disaster database, Université Catholique de Louvain, Belgium; World Factbook.

India is also estimated to have suffered direct losses in excess of $9 billion over the five years from 1996 to 2000, reflecting loss estimates on approximately 20% of the reported catastrophe events during the period.[4] These have disproportionately affected the poor[5], although this is largely unrecorded in the monetary loss data. In addition to killing people and destroying property and infrastructure, natural disasters can have lasting economic and social effects[6], including a reallocation of income both geographically and between social groups.

State level taxation and private insurance mechanisms (see below) are relatively underdeveloped in India and in practice the major responsibility for ex post funding of relief and recovery has rested, directly and indirectly, with budget transfers from the central government. Every Finance Commission since the Second has devoted a full chapter to calamity relief funding. In the last decade the situation has been exacerbated by the fact that most states and the central government have been running deficits on their revenue accounts because of burgeoning current

[4] Direct losses refers to losses of economic capital or stock, but in practice published insurance losses include any insured loss of profits. Indirect losses refers to flow items such as GDP. See Litan (1999) for a full discussion of natural disaster loss metrics.

[5] See for example Bhatt (1999).

[6] Anderson (1995) has pointed out that indirect economic losses tend to be larger relative to direct material costs in poor countries than in rich countries. Litan (1999) points to evidence that indirect losses constitute a larger fraction of total losses for large disasters.

expenditures, and resources for post disaster reconstruction in particular have been increasingly constrained and dependent on donor funding.[7]

Given this background and a clearly expressed concern on the part of the Indian authorities as fiscal pressures grow, the World Bank undertook a detailed review of India's catastrophe exposures, with in depth studies in four states. The purpose of the mission was to examine the loss potentials from rapid onset natural disasters and to consider the opportunity to apply enhanced country and state level risk management techniques, with a particular emphasis on the financing of post disaster reconstruction and the efficient allocation of public funds.

The role of insurance markets in has been examined given their contribution to the effective transfer of private sector catastrophe risk in other jurisdictions, but relatively insignificant role in India. In 1999, which is one of the worst years on record for natural hazard related insurance losses, South Asian countries did not rate among the top 20 in terms of insurance losses; however, they did account for five of the 20 worst events in terms of lives lost. Despite having close to a fifth of the world population, South Asia only accounts for about 0.3% of global non-life insurance premiums. The region, to all intents and purposes, has not been a serious participant in the global markets for disaster loss risk transfer.

This exercise focuses on rapid onset disasters. It is true that droughts affect more people than other natural disasters (Table 2) and their cumulative indirect economic effects can be substantial over time. However, direct losses tend to be substantially smaller for droughts than for rapid onset disasters. Because slow onset disasters such as drought have different characteristics from and are more difficult to quantify than rapid onset events, they would require a separate study using a different risk management paradigm than the one applied in this study. This dichotomy of natural hazard risk was discussed by the Seventh Finance Commission but is not currently recognized in India's expenditure planning and revenue sharing processes. Given weather insurance and other rapidly developing technologies in this area, some investment in investigating and perhaps even pilot testing ex ante funding of slow onset disasters may now be justified.

Table 2: Drought Incidence in India

Number of Disaster Events		Period	People Affected –millions	
Total	Drought		Total	Drought
121	8	1965 - 1980	662	500
181	5	1980 - 1995	849	502
75	4	1996 - 2001	283	90

Source: CRED, International disaster database, Université Catholique de Louvain, Belgium.

[7] McCarten (2003).

I. Natural Disasters Pose a Threat To India's Fiscal and Economic Development and Justify a Formal Risk Management Approach

Disaster Exposure/ History – India has a significant exposure to natural hazards; 55% of India's land is vulnerable to earthquake, 8% is vulnerable to cyclone and 5% is vulnerable to flood.[8] Demographic and economic trends in the past three decades have magnified the actual and potential impact of natural disasters.[9] Additionally, there is growing evidence that calamities can contribute to environmental degradation leading to a vicious cycle of increasing disaster impacts.[10]

India has a long coastline, which is exposed to tropical cyclones, especially along its eastern coastline. Around 85 cyclones from the Bay of Bengal and Arabian Sea have affected the country over the past 35 years: in November 1996 over 7 million people were displaced when a major cyclone hit Andhra Pradesh. These cyclones are frequently accompanied by tidal waves. Low-lying lands, typical of the Eastern shore of India, permit storm surges of even a few meters to intrude far into the hinterland, causing widespread flooding and seawater incursion.

Flooding is a common phenomenon in India and is exacerbated due to the silting up of rivers, reduced soil absorption, lack of urban planning, and deforestation. Floods are caused due to heavy rainfall during the three to four month long monsoon season. Large floods occurred in 1997 and 1998. Heavy monsoon rains flooded South West India in 1997 and affected Assam, Bihar, and Andhra Pradesh in 1998. Recent flooding events have been aggravated by increased urbanization and unplanned growth. For example, in Mumbai, where migration has increased the population significantly, large segments of the population live in unauthorized slums close to drainage systems. Because of these settlements, the width of the "nallas" (man-made canals for sewage water and refuse) are reduced and the accumulation of solid waste causes inner city floods.

As noted above, about half of India is exposed to earthquakes. The vulnerable areas are mostly in Himalayan and sub-Himalayan regions, and in Andaman and Nicobar Islands (Vinod, 1999). The most recent earthquake occurred on January 26, 2001, and mainly affected the state of Gujarat. The Gujarat earthquake, which measured 6.9 on the Richter scale[11], is considered one of worst single disasters of the decade, causing severe destruction to buildings and other property in Bhuj, in the Kutch district, and several urban cities including Ahmedabad. This earthquake affected 182 talukas covering 7,904 villages in 16 districts of Gujarat: 13,800 people were reported killed and more than 167,000 injured. Nearly one million residences were destroyed completely or partially.

More than 360 natural disasters have been recorded over the past 35 years and the frequency has been increasing (see Annex I). The number of reported events increased by around 50% during the 15-year period 1981-1995 (181 events or 15 per year) compared to the previous period 1965-

[8] Dheri, in Sahni et al. (2001)

[9] For a disaster to occur human lives and property need to be exposed and the frequency of disasters should not be confused with the frequency of natural events.

[10] See joint UNEP/OCHA Environmental Unit Environmental Emergency Notification (ENRA) for a taxonomy.

[11] India Meteorological Department figure. Other sources gave higher values.

1980 (121 events or 8 per year). This trend has continued in recent years with 75 events reported in India during the period 1996-2001 (Table 3).

Table 3: Disaster History by Major Hazard in India, 1996-2001

Hazard	No. of reported events	No. of reported deaths (thousands)	People affected (thousands)	Reported losses ($million)	No. of loss reports submitted	Percent reported	Average loss per report ($million)
Windstorm	15	14.6	25,213.7	5,619	15	100	374.6
Flood	29	8.9	150,980.3	2,928	18	62	162.7
Earthquake	3	20.1	16,367.0	4,707	6	200	784.5
Drought	4		90,000.0	588			
Other	24	5.9	356.9		3	13	
Total	75		282,917.9	13,842		56	329.6

Source: CRED, International disaster database, Université Catholique de Louvain, Belgium.

Economic and Fiscal Impacts - Reported direct losses on public and private economic infrastructure in India have amounted to approximately $30 billion over the past 35 years (nominal values at then applying exchange rates). Since less than 25% of the registered loss events actually provide any loss estimates, the official numbers substantially understate the true economic impact of direct losses. A crude grossing up for reporting frequency indicates that direct natural disasters losses equate to up to 2% of India's GDP and up to 12% of federal government revenues (Table 4).

Table 4: Reported Natural Catastrophe Losses, 1996-2000

South Asia country	Reported incidents	Percentage assessed	Reported losses	GDP[1] *[$ mill.]*	Government revenues[2]	- Loss intensities - *pct. GDP*	*pct. revenues*
India	73	19.2%	$9,176	$407,850	$75,500	2.25%	12.15%
Pakista	22	0.0%		$52,280	$9,150		
Afghanista	20	0.0%		$3,895			
Banglades	48	8.3%	$2,879	$37,650	$4,360	7.65%	66.03%
Sri	9	0.0%		$11,625	$2,185		
Bhuta	0	0.0%		$430	$165		
Nepal	15	26.7%	$52	$6,250	$690	0.84%	7.58%
	187	7.7%	$12,107	$519,980	$92,050	3.58%	13.15%

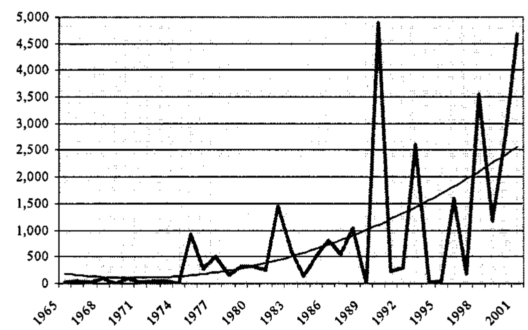
[1] Estimates based on factor income data, current foreign exchange rates, and extrapolation of comparative country figures.
[2] Estimates based on comparative data on central government and state government operations.

Sources: CRED, International disaster database, Université Catholique de Louvain, Belgium; International Monetary Fund, Recent Economic Developments - Country Report Series; World Factbook.

Furthermore, the reported monetary losses seem to be increasing (Chart 1). Reported direct losses from natural catastrophes more than quadrupled during the 15-year period 1981-1995 ($13.4 billion) compared to the losses registered during the previous 15 years ($2.9 billion). This alarming trend is continuing with total losses of $13.8 billion reported during the period from 1996-2001 (Table 3). Hence, the losses reported during the most recent six-year period have, in nominal dollars, already exceeded total losses incurred over the previous 15-year period.

The economic impact of natural disasters extends beyond the directly measurable losses on economic infrastructure. There are often significant secondary effects and indirect losses associated with natural disasters. For example, the destruction of productive assets and public infrastructure inhibits economic activity, while the increased demand for public expenditures for relief and recovery disrupts fiscal planning and prejudices public and private capital investment. Numerous studies carried out in the last decade confirm the negative short term economic and social impacts of natural disasters.[12] A World Bank/ ADB assessment report estimated that the Bhuj earthquake caused a $491-655 million loss of output and had a $2.2 billion negative impact over three years on Gujarat's fiscal position. The medium to longer term impact of natural disasters has been examined in a number of studies and the results are ambiguous, although it appears clear that both the timely availability of funding post disaster and institutional capabilities affect the extent and sustainability of recovery.

Chart 1: Reported Catastrophe Losses in India, 1965-2001
Nominal US$ Million at then applying exchange rates



Source: CRED, International Disaster Database, Université Catholique de Louvain, Belgium.

Discussions on natural calamities have been part of the fiscal scene in India since the Second Financial Commission first focused on the problem. Every subsequent report has dedicated a complete chapter to the topic. More recently, the Tenth Planning Commission devoted a whole chapter to the development implications of natural disasters, with a particular emphasis on disaster management, prevention and mitigation. In late 2001, a High Powered Committee on Disaster Management submitted a report which recommended that 10% of Plan Funds[13] at the national, state and district levels be earmarked and apportioned for prevention, reduction, preparedness and mitigation of disasters.

The evolution of disasters funding in India largely reflects the five year fiscal planning cycle and has been shaped by the federal structure of the country. The Constitution does not directly specify which level of government is responsible for managing disasters. By convention, this

[12] See for example Benson (1997).
[13] India follows a plan approach to economic management and plan funds are those relating to items appearing in the Plan. Non-plan funds largely cover ongoing expenditures.

responsibility has been taken up by individual states while the federal government provides financial support. The history of formal post disaster funding in India can be captured along four vectors:

1. **What is funded.** This has generally been divided into three distinct categories, namely gratuitous relief (including emergency water, food and shelter, drainage works and seed), relief work on plan projects as a better alternative to gratuitous relief, and repairs and reconstruction of government assets.
2. **The funding role of the central government**, which also has three categories. Normal transfers to the states under the tax sharing arrangements (this allowed for a margin for calamity relief from the Second to the Ninth Finance Commissions, when the Calamity Relief Fund (CRF) was established), advances against the current Plan, and supplementary transfers from the federal level in the event of catastrophic losses.
3. **The nature of federal supplements**, which can be straight grant, loan or advance. In practice a large portion of the loans and advances become de facto grants. The national Calamity Relief Fund was established when this was recognized.
4. **The nature of the event.** The Sixth, Seventh and Eighth Finance Commissions recognized that droughts have different characteristics from other natural calamities and are best responded to with heavy investment in relief works.

The approaches adopted from time to time have reflected the ongoing tension between the central government's concern, on one hand, about fiscal discipline and efficient use of funds and, on the other hand, the reality of the growing intensity of natural disasters and deteriorating state fiscal positions. While there have been many ad hoc adjustments over the last five decades, particularly with regard to the nature of central supplementary transfers, the funding arrangements can essentially be divided into three main periods:

Second to Sixth Finance Commissions – During this period an explicit margin for relief, usually including relief works, was built into state non-Plan budget planning. Excess requirements over the margin were partly or wholly met by the central government through combinations of grant and lending. Repairs and restoration tended to be handled through Plan supplements, advances and development loans. There was an ongoing debate as to whether relief works came under Plan or non-Plan heads. As costs grew, various controls were built in including the involvement of central inspection teams and the introduction of ex post expenditure ceilings. Ceilings were removed in 1972/73 but expenditures grew rapidly and the Sixth Finance Commission called for states to live within their Plan allocations and for disaster funding to become an integral part of the planning process.

Seventh and Eighth Finance Commissions – The dictates of the Sixth Commission proved to be impossible to sustain in practice and central advances against repairs and reconstruction crept back in (in 1975/76 over 90% of advance Plan assistance was for reconstruction and replacement of roads, buildings, flood control, irrigation works and other public assets). The Seventh Commission reiterated that Plan assistance should only be available for the creation of new assets and recommended that repairs and reconstruction should become part of the non-Plan margin allowance, with 75% of the excess over the margin being met through grants by the central government. However, the commission also recommended that drought associated relief expenditures which require new investment should be transferred to the relevant state's Plan. Up to 5% of additional Plan funds were available for this purpose in any year, as an advance against future Plan allocations. In the event of extreme disasters the center would contribute via grants and loans.

Ninth to Eleventh Finance Commissions – The Ninth Finance Commission proposed the cancellation of the marginal funding approach with heavy intervention from the central level and instead introduced the Calamity Relief Fund, with the central government contributing 75% in the form of non-Plan grants. Any balance in the Fund could be carried forward to future Plan periods, and in the event of heavy calamity expenditures up to 25% of the following year's central allocation could be drawn upon. The Ninth Commission also began to canvass the idea of an "Expert Group" to monitor the actions of the states, but restricted this to relief work. The Tenth Finance Commission introduced the National Calamity Relief Fund (NCRF), managed by a National Calamity Relief Committee (NCRC), to cover calamities of rare severity. However, the states allegedly then projected "any calamity as one of rare severity," resulting in an upward trend in relief requests (Table 5). Central control processes, including visiting teams, had to be reintroduced. In practice it was sometimes found that funds disbursed had not been employed even after considerable periods. The Eleventh Finance Commission modified the Ninth by restricting capital expenditures from the CRF to items that provide immediate relief to the affected population and are of short duration. Reconstruction and repair were reallocated to Plan funds "on priority" and the distinction between drought and other calamities was removed. The Eleventh Finance Commission also proposed a role for the insurance markets and recommended the creation of a National Center for Calamity Management (NCCM) to provide advice to the central government on the ex post financing of calamity recovery efforts. In many ways it anticipated the recommendations of this report (see Chapter V) and has been included as Appendix IV.

The Twelfth Financial Commission, which has to report by April 2004, has been asked to look, once again, at this topic.

Table 5: NCCF disbursements all states (Rs Million)

Year	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Total	2,774	4,971	12,910	9242	13,687	16,000

Source: MOF, Finance Commission Reports (www.fincomindia.nic.in).

Key elements of the current approach are as follows:

- The Calamity Relief Fund meets immediate relief needs for the victims of cyclone, drought, earthquake, fire, flood and hailstorm. Under this arrangement a Calamity Relief Fund (CRF) is constituted in each state to receive funds, 75% of which come from the central level in the form of non-plan grants. Individual state funding levels are based on relatively short term averages, adjusted for inflation and mitigation efforts.[14] Central government transfers are subject to receipt of evidence from the states that the funding of the CRF is being appropriately managed. States may also draw on up to 25% of central funds due in the following year, subject to subsequent adjustment. The state CRFs are administered by committees consisting of officials connected with relief work or who

[14] This is consistent with the Arrow – Lind (1970) expected cost formulation for nations, but as Mechler (2002) has demonstrated, the underlying assumptions break down for highly vulnerable developing countries such as India, as shown by the fact that extreme events have had to be discounted in the past in arriving at CRF allocations. The Arrow - Lind work built on work by Hirshleifer (1966) and made it clear that in second best situations public investment could replace private investment.

have expertise in the natural calamity field. A state committee is responsible for ensuring that money drawn from the CRF is applied only to expenditure items approved by the Minister of Home Affairs. CRF funds are to be invested in prescribed assets to ensure their availability when needed. CRF funds may be applied to existing capital works, but only if this is required for the provision of immediate relief, such as restoration of drinking water and shelter. Other capital restoration has to be funded, from state plan funds, if necessary by reallocation, and can include donor contributions. Unused CRF funds may be carried forward to the next fiscal planning period.

- Following a severe disaster, the central National Calamity Contingency Fund (NCCF) meets relief expenditures in excess of a state's CRF fund, subject to oversight by the National Center for Calamity Management (NCCM), constituted by the Ministry of Home Affairs. The NCCM monitors the occurrence and impact of the hazards mentioned above under the CRF. Funds are released to states after a decision by a High Level Committee on Calamity Relief. Assistance provided to the states by the central government from the NCCF is financed by an immediate levy of a special surcharge on federal taxes for a limited period.

Overall, there is very limited scope to fund the restoration of infrastructure from the formal disaster relief funding mechanisms currently in place. Instead, as noted earlier, states are required to maintain infrastructure from Plan funds. Plan funds have become increasingly constrained because an increasing level of public sector borrowing is required to fill gaps in the aggregate national revenue account.[15] There is also some uncertainty over the capacity of some states to effectively employ capital funds, especially when implementation needs to be expedited.[16]

Post Bhuj (Gujarat, 1999) earthquake reconstruction and rehabilitation expenditures provides a contemporary snapshot of the reality of reconstruction funding in India (Chart 2).

An analysis demonstrates:

1. The dependency of the states, even relatively wealthy states such as Gujurat, on external funding, from and through the central government when massive reconstruction and repair is required.

2. Substantial resources were allocated to housing reconstruction (rather than infrastructure or drought relief works). In Gujarat, house owners well above the poverty line became eligible for government supported reconstruction.

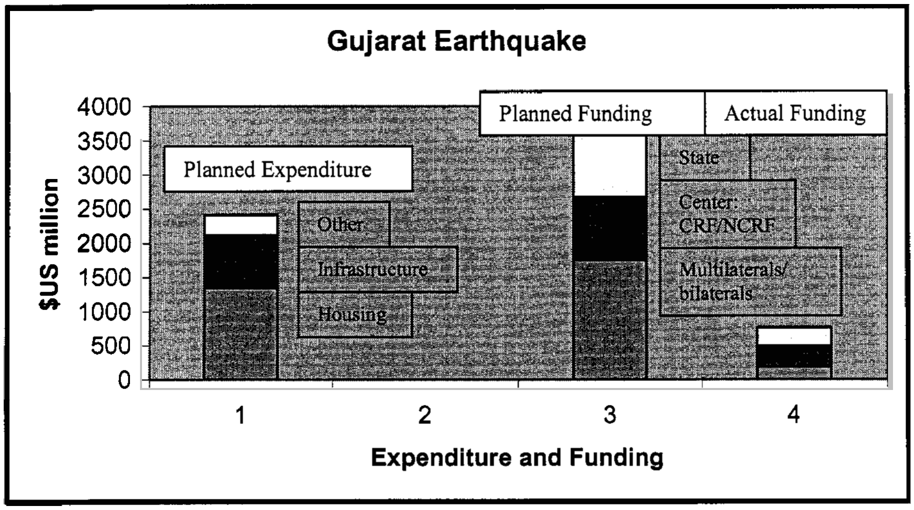
3. The very slow and in some cases non-existent disbursement of funds under current ex post funding arrangements. This almost certainly reflects institutional weaknesses as well as funding issues, however the relative contributions are not clear. At the very least it is possible to say that there is a joint funding/capability gap.

---

[15] McCarten (2003).

[16] Anand (1999), Eleventh Finance Commission Report, section 9.27.

Chart 2: Bhuj (Gujarat) Earthquake Funding/Capability Gap - End 2002



Source: MOF (see Annex VI for detailed analysis).

Further evidence of the limitations of the current approach can be found by examining two recent disasters in Andra Pradesh (AP), the November 1996 cyclone (affecting the East and West Godavari Districts of AP with 120 knot winds) and the October 2001 floods (affecting four districts). Memoranda summarizing total damages to major public and private sectors for both events were prepared by the Relief Department. A request was also made for relief funding from the Government of India.

Data summarizing AP's post disaster experience in 1996 and 2001 can be found in Annex V; this includes data on damage estimates and relief requests by sector. The analysis compares damage estimates by sector to the capital budgets for the year of the event, although it was not possible to compare line by line budgets with damage estimates due to reporting differences in 1996 and 2001. The table also allocates funds received from the GoI to different sectors. Major conclusions drawn from the data include:

- Private housing accounted for very large losses in both events, while horticulture suffered enormously in the 1996 cyclone. Both sectors are viewed by AP finance officials as primarily private sector activities

- The natural disaster funding gap between damages within AP and funds received from the central government is very large. The percent of damage to the public sector not funded by the center was 98% for the 2002 floods and 96% for the 1996 cyclone. After allowing that the original damage estimates are probably inflated, it is still clear that the state still bore most of the losses. As these events do not represent the full range of natural calamity severity, it is possible that future events of a higher severity would have smaller funding gaps because of larger assistance from the GoI and international sources. However the absolute financial burden on AP would in all probability be higher in such a case.

- Damage to the public sector as a percent of AP's capital budget is estimated to be 16% for the floods and 80% for the much more severe cyclone. Each event also affected the public sectors differently, with roads being more susceptible to flooding, while electric power was more affected by cyclonic winds.

- No damage data is available for the private commercial sector. The government has indicated that businesses are expected to buy insurance or otherwise take full responsibility for their losses from natural disasters. After the 1996 cyclone, private commercial sector firms applied for government assistance but were denied any assistance by the state.

Thus, the state of AP relied in practice largely on its own resources and other sources of funding rather than on the center for funding reconstruction of damaged assets. Discussions with state finance officials indicate that as a matter of practice, the state does not borrow any funds from the center or from banks specifically to fund reconstruction. As there is no other likely source of funds, reconstruction is funded by reallocating current budgets. Losses occurring early in the fiscal year before budgets are fully committed are likely to be funded earlier than events occurring later in the year. Should current budgets prove inflexible, budgets from future years will be reprioritized to fund reconstruction at a future time. Such a process results in delayed restoration of important assets, usually only to a level of minimum functionality. This is likely to lead to heightened maintenance and substandard reconstruction, with attendant future costs because such reconstruction may be more vulnerable to future natural disasters. Government road officials estimated that it took over two years to replace lost roads from the 1996 cyclone and some roads and bridges may have been abandoned. In summary, the expected future lives of some of the assets will be reduced, while future infrastructure projects necessary to support a growing economy will not be constructed. Substandard capital investment over the long term will retard economic growth in the state.

The current funding approach clearly involves a reactive response to each event. Minimal proactive effort is applied to reducing the future financial and human costs through mitigation, land planning, improved building codes and construction practices, and ex ante funding programs that provide immediate funds for reconstruction. Without adoption of modern risk management programs, the current lack of proactive risk management practices will exacerbate future financial losses. This effect will be greater with increases in the population and supporting infrastructure.

Application of ex ante intellectual and financial capital is the recommended approach for assisting Indian states in managing their catastrophic risk. Earthquakes, cyclones and floods will continue to affect India, but their human and financial costs can be reduced.

II. Disaster Loss Funding Strategies Need To Be Instituted As Part Of A Formal Risk Management Approach

In the larger industrial countries natural disaster recovery is typically funded through a combination of private insurance arrangements and an efficient public revenue system relying on wide and deep taxation catchments. In the case of developing countries, which have relatively low tax ratios and ongoing fiscal pressures, funding sources for post disaster reconstruction tend to be more varied, with a strong emphasis on assistance from international donors.[17] The most common sources of such funding are multilaterally sourced infrastructure loans and relief aid from donor agencies.[18] Some countries have explicitly factored these sources into their fiscal planning by ensuring that they would have co-funding immediately available in the event of a disaster, and taking steps to make their international public relations efforts effective.[19] [20]

As Mechler (2002) has pointed out, contrary to the standard Arrow and Lind (1970) formulation, "a number of developing countries with high natural hazard exposure and a limited ability to cope with disaster impacts need to be risk averse to natural risk." To this end, the World Bank has been developing a country risk management model which is partly based on corporate risk management principles[21] but also factors in key economic and social metrics such as government fiscal profiles, the living conditions of the poor and investments in risk mitigation. The methodological framework (described in Figure 1) implicitly assumes a growth oriented development model appropriately modified by risk management and distributional objectives.[22] The first step under this methodology involves assessing potential losses from natural hazards on a probabilistic basis (see Chapter III). While loss control planning is implied to be a distinct activity by the model, price discovery signals indicated through the risk funding and transfer markets often act as a positive influence in directing the mitigation effort.

Once the assessment of potential losses is complete, the second step in this methodology is to determine how an array of risk reduction techniques (mitigation) can be used to reduce the identified loss exposures. Reducing the loss from future catastrophic events should be an essential part of any risk management program. The most beneficial mitigation programs are those that are implemented before or at the time of new construction, when the incremental cost of adding disaster-resistant design features to withstand wind, water or shake forces is usually a small percentage of the total capital cost.

---

17 McCarten (2003) points out that capital expenditures by the states have declined from 31% of their revenue aggregates in 1980/81 to 17% in 1996/97. Investment in power, irrigation, roads and urban infrastructure has stagnated and operations and maintenance expenditures have declined.

18 Phase 1 of the Gujarat Earthquake Emergency Reconstruction Program, 2001, was financed by re-allocating the proceeds of one loan and eleven credit agreements already approved or already active.

19 See the case of Bolivia in Freeman and Martin (May 2002)

20 In this regard a number of commentators have compared the coordinated and very effective performance of the Central American States after hurricane Mitch and the relative lack of coordination of the Caribbean states after hurricane George. India does not make requests for post disaster aid as a matter of policy, but accepts assistance offered suo moto.

21 Doherty (2000).

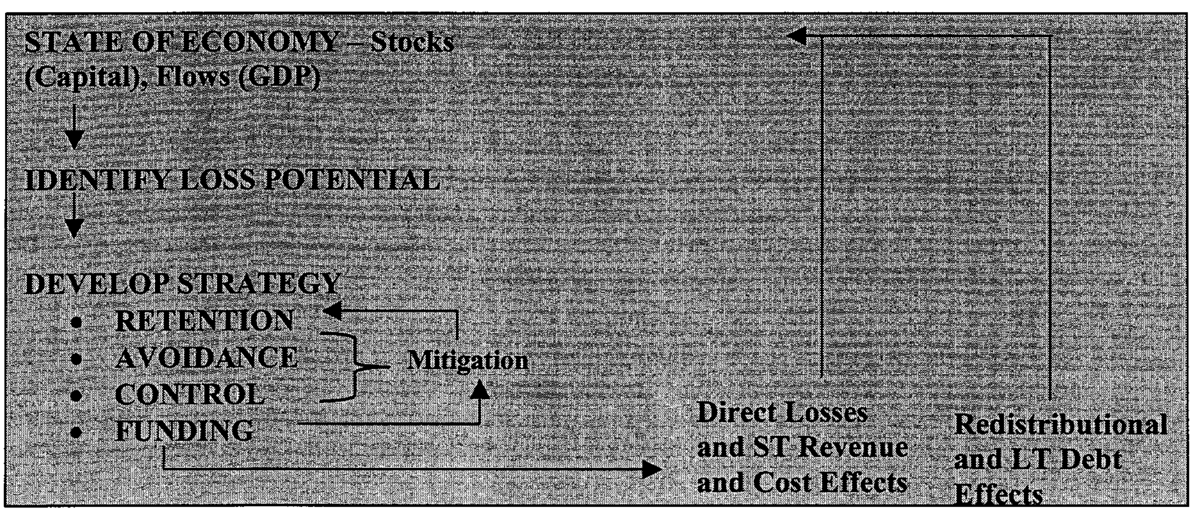
22 J.M. Albara Bertrand (1994) and others have argued that the growth model increases vulnerability and should be modified, but this debate is outside the scope of this paper, which seeks better solutions within the existing paradigm.

Land use planning can also provide substantial risk reduction benefits, by banning or freezing construction in areas prone to wind/wave/ erosion/landslide/liquefaction/earth quake faulting/ or ground settlement.

Other mitigation projects, involving retrofitting buildings originally constructed with little attention to their disaster resistance performance will be more expensive than for new buildings, pointig to the importance of adequate enforcement of construction codes through on-site inspections at the construction stage. Even for poorly constructed buildings such measures as providing roof tie downs for anti-cyclone design improvements, is often a worthwhile improvement. Other measures for flood control via levees and drainage culverts can also be very cost effective. In general, mitigation is more cost effective against events which occur with higher frequency, since the benefit of the mitigation will be higher the more times the event occurs. Conversely, mitigating for events with very low frequencies will probably not be economical, and it is in those situations where risk transfer via insurance is likely to prove more cost effective.

The third stage of the described decision model is to provide guidance as to the most effective funding and risk transfer mechanisms, allowing for longer term economic and social imperatives. In this regard Freeman and Martin in examining optimal natural disaster funding arrangements for four Latin American and Caribbean countries have built on a framework outlined by UNCTAD in a 1995 study.[23] The methodology they have developed takes a formal and structured approach to the funding question, and in particular identifies what is called the "natural disasters resource gap," which is the difference between the expected fiscal cost of an event and known ex post sources of government funding that could be tapped. As there is inevitably a positive and usually non-linear correlation between the severity of an event and its rarity, the resource gap itself is a non linear function of event frequency. This non-linearity is further complicated by the fact that aid and other resources are themselves likely to vary according to the nature and size of a catastrophe.

Figure 1: Country/State Risk Management Model



[23] UNCTAD (1995).

The following table (Table 6) illustrates the presentation of these results in a format that would support policy decisions.

Table 6: Funding Gap Reconstruction and Rehabilitation

	50 Year Event	100 Year Event	150 Year Event
Government's post disaster commitment			
1.Lifeline infrastructure replacement 2.Provision of living needs of the poor 3. High return and sustainable mitigation investment 4.Other infrastructure 5. Other housing			
Ex post sources of funds			
Aid			
Central funds transfer			
Budget reallocation			
Tax surcharge			
Domestic credit			
Development Banks			
Other external Credit			
Ex post funding gap			

In practice it is considered unrealistic for cognitive, financial and political reasons to expect governments with inherently limited resources to provide for extremely rare events in their fiscal planning. However, the mission team believe good economic management would cater for events with a probability of 1% or more of occurring.

The main types of ex post funding, with the possible exception of direct cash aid, have potential costs as well as benefits (see Box 1). Despite this, experience to date indicates that governments, especially those running fiscal deficits, will usually employ ex post funding before resorting to ex ante funding arrangements. The main ex post sources of funds are redirected budget, direct aid, tax increases, diverted loans (usually involving the development banks), and increased borrowings including from the central bank.[24] Direct aid is assumed to be an important source of funds in some of the models now being developed. However, experience to date indicates that only a small proportion of this is usually in the form of cash and available for reconstruction.[25] In addition, international aid as a source has been relatively static.[26] Diversion of already approved development loans is also seen to be attractive source largely because this can usually be effected with fewer bureaucratic roadblocks and conditionalities than are involved in producing new loan arrangements. Taxation is probably the next most popular ex post funding source, although this is normally partly offset by exemptions and deferrals given to those affected by the event.

[24] This is frowned upon by the international financial institutions and is ultra vires in some countries.
[25] Freeman (2002) estimates that globally, approximately 9% of direct stock losses are covered by direct aid on average.
[26] OECD DAC www1.oecd.org/dac/htm/aidglancehome.htm.

Box 1: Tradeoffs in Ex Post Funding

Sources of ex post funding involve tradeoffs and often have economic costs. Development loans diverted to reconstruction potentially provide the most obvious case, as it is unlikely that the economic return from reconstruction, particularly that of housing, will be as high as the return from the loan's originally intended purpose. Increased borrowings may affect a state or country's long term credit rating and capacity to borrow, increasing the opportunity costs of other investments. Central bank money creation can have a similar impact, and this can potentially be compounded by higher inflation. Diverted current consumption budgets presumably mean that what were optimal choices before the disaster are no longer possible. Increased taxes, if significant and sustained, can lead to a loss of existing economic activity and discourage new investment. Even direct aid could have a long term downside if incentives for mitigation are adversely affected, although it clearly dominates all other alternatives.

The only practical way of comparing the different funding options would be to run many simulations of the future based on probabilistic loss scenarios. This would provide a range of possible futures for each funding portfolio chosen (given the policy setting) and an appropriate optimization criterion could then be applied.

Even if funds are available, public sector delivery mechanisms can pose challenges. This is not just a developing country problem, however the situation is exacerbated in a poorer economic environment, and there is a need to develop transparent and objective aid allocation triggers and guidelines. For example, after the Latur earthquake of 1993, illiterate widows, unaware of the laws, lost out on reconstruction or home replacement aid[27], and, as a general observation, existing channels of distribution of government assistance to affected people have been costly and inefficient. It is estimated that in India only one-fourth of government assistance expenditures reach the intended beneficiary.[28] In addition, and as noted in the previous chapter, much of the available funding is often not employed, reflecting a lack of planning and limited relevant human and other resources and inadequate institutional capacity.

The four generic ex ante funding methodologies are risk transfer (usually specialized catastrophe insurance and reinsurance), the establishment of insurance reserve funds (backed by hedging instruments such as reinsurance), inter-temporal smoothing (finite reinsurance) and the arrangement of contingent debt facilities.[29] It can be easily demonstrated that fairly priced insurance usually dominates the other three alternatives in the case of infrequent catastrophic events. The main reasons for this are related to timing and human nature; insurance reserve funds without an insurance base or other financial support will typically take decades to reach sufficiency and in the interim are subject to political bids and the possibility of investment losses. Contingent debt can often be arranged; however, simulations demonstrate that if commercial interest rates are applied, contingent debt is a superior approach to insurance only if a disaster happens relatively quickly after the facility is established or if the price of insurance becomes excessive.[30] In addition, experience to date indicates that some countries are able to borrow on unchanged terms after a natural disaster, making the facility and arrangement fees a deadweight cost. A combination of insurance, reserve funds and contingent debt can be optimal when

[27] World Disaster Report (2001), page 21.
[28] Per discussion with Joint Secretary (Expenditure), Ministry of Finance, Government of India, New Delhi.
[29] Stand alone reserve funds are so clearly inferior to the other alternatives for low frequency events that they have been ignored. They may have a role for less severe more frequent events, along with finite reinsurance.
[30] Freeman (2002).

reinsurance prices peak or if the contingent debt approximates grant money (e.g. IDA facilities). Inter-temporal smoothing by its very nature is best suited to more frequent less severe events. Thus insurance can dominate on the basis of timing benefits alone. It may also lead to marginal economic benefits when opportunity costs, behavioral affects and variability are taken into account. For example, if insurance changes economic behavior by enabling economic agents to pursue riskier but more productive activities it can have a permanent positive impact on the economy, independent of the consumption smoothing benefits it creates. Giles and Bigger (2000) in an economic study for Turkey state that "under the assumption that individuals withhold 30% of their savings and firms withhold 15% of their capital for the purposes of self-insurance, we find that an economy operating without insurance operates at 8% below potential GDP." [31] Insurance can act conceptually as a signaling advice if pricing accurately reflects risk levels and is passed on to the consumer, encouraging cost effective mitigation and appropriate avoidance behavior, such as not building on flood plains.

Equilibrium modeling also raises questions about the returns obtained from the alternative allocations of post disaster funding.[32] As mentioned earlier, governments normally allocate priority to the replacement of essential infrastructure and to basic consumption maintenance for the poor (particularly in rural areas). The replacement of key productive public infrastructure is hardly controversial, and it has been amply demonstrated that the poor suffer disproportionately from natural disasters.[33] As Lavall has pointed out, the use of economic criteria and cost-benefit equations for attempting to justify risk mitigation and reduction may reap rewards for the modern sector economy, but this is not necessarily the case for the poor and traditional sectors that make up the majority of the victims of disaster.[34] The attainment of more secure living conditions for the poor and a substantial reduction in their vulnerability is more a case of ethics and social justice than of economic rationale and efficiency.

A more questionable area where political pressure often leads to misallocation of scarce government resources is reconstruction of private housing in the aftermath of natural disasters for those who normally would not be viewed as poor.[35] This use of funds is of marginal economic benefit. In fact the direct allocation of government support to the small business sector would probably have a much greater impact on restoring economic activity, although this is an equally questionable use of public funds if insurance is available. In practice, formal government support to the small business sector (including cash crop farmers) after a disaster is normally restricted to the relaxation of credit terms from banks and other lenders.

The only way governments can avoid political pressures on the housing front from the better off sections of society is to ensure that a fairly priced catastrophe insurance product is available and that those who can afford it are either required to purchase it, or at least have a good incentive to do so. This requires that they are in turn sufficiently convinced that the government will not assist them in replacing or repairing their property in the event of a future disaster (see Appendix II).

[31] This employed a two stage approach using standard loss modeling in stage one to provide inputs into a static equilibrium model.
[32] Lahiri et al. (2001) have also raised this issue based on pragmatic observation.
[33] See for example Annual Disaster Report, Red Cross and Red Crescent (2001).
[34] A. Lavall (1999).
[35] See R. Gibert (2001) for a full discussion of issues relating to the post disaster funding of housing reconstruction.

A complication in India is the prevalence of informal housing, reflecting the large sections of the Indian economy that operate outside the formal economy. Thus any mandated scheme may appear to be inequitable given that many of those in the informal sector, such as small business people, have greater financial resources than those in the formal sector, a high proportion of whom are low paid government employees. However, government reconstruction support for informal sector housing is likely to support the rapid revival of the SME sector after a disaster and can possibly be justified on these grounds alone. Thus any practical approach in the foreseeable future is likely to be built around protecting the balance sheets of the housing finance intermediaries (see Chapter V, Annex VII and Appendix V) and possibly mandating insurance for registered housing, subject to income level.

A further possible legitimate use of public resources involves the enhancement of mitigation and disaster recovery capacity. Unfortunately, the measurement and cognitive challenges to justifying mitigation expenditure are even greater than for insurance.[36] Discussions with local officials point to two key criteria for investing in mitigation in India. The first is that it clearly saves lives and the second is that sufficient ongoing funds will be available to sustain the effort.

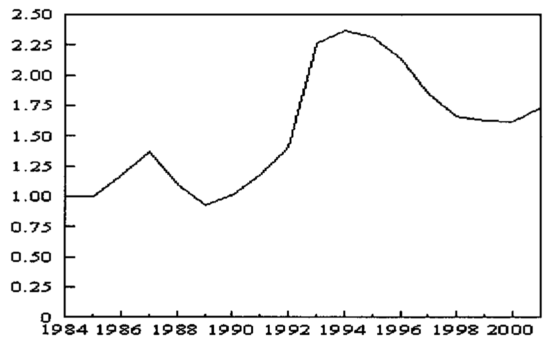
Even in wealthy countries with well developed insurance markets the loss potential can be so large that the insurance markets are unable to provide sufficient capacity at acceptable prices. In some of these cases, special state mandated catastrophe insurance arrangements have been made, usually in the form of a private/public partnership riding on the base of the private insurance system. Industrial countries and states with such arrangements include France, California, Florida, New Zealand, Norway and more recently Taiwan (see Appendix I). In addition, some of the wealthier industrial countries provide subsidies through specialized government catastrophe insurers, such as the National Flood Insurance Program in the U.S. A number of countries with less developed private insurance systems have implemented or are considering implementing a variation on this modality, which involves the establishment of a mandatory specialist catastrophe insurance mutual, but with the private sector having a distribution role. The Turkish earthquake pool is probably the best known of these more recent efforts and has become the basic model for other transition and post transition jurisdictions.

The main purpose of catastrophe pools is to act as efficient intermediaries between the ultimate consumer and reinsurance markets. In addition, because reinsurance capacity and pricing can be highly volatile (Chart 3 shows rate variation for the U.S. prior to September 2001) the pools need to accumulate sufficient funds to be able to smooth the domestic cost of risk transfer by varying the level of local risk retention. Further financial support and smoothing capacity can be arranged in the form of contingent debt; international financial institutions have recently shown a willingness to provide such facilities.

[36] See P. Kleindorfer and H. Kunreuther (2000).

Chart 3: Reinsurance Pricing Volatility

(1984 = 1.00)



Source: Congressional Budget Office based on data from Paragon Reinsurance Risk Management Services.

In the case of India, the situation is complicated by the center/state flows of information and funds described earlier and in Annex IV. In practice there is no guarantee that the funds made available are appropriate either in terms of quantum or allocation and a more rigorous and objective approach, based on the methodology described above, is desirable. Given that reconstruction funds at the margin are often sourced de facto if not de jure (loans and advances have often been forgiven) from the central government, there is substantial scope for the center to develop incentives for the states to adopt rigorous ex ante risk funding and mitigation approaches to natural disasters in an effort to control further fiscal blow outs and optimize resource allocation. Options and recommendations as to how incentives could be incorporated into an integrated funding, mitigation and advisory institutional framework appear in Chapter V.

III. Catastrophe Risk Models Point To Different State Level Loss Potentials and Risk Management Imperatives[37]

The first step in the risk management model described in the previous chapter involves a detailed assessment of loss potential in the jurisdictions of interest. Given the costs of such studies, an initial broad filter is applied, often based on historical patterns, to determine which specific exposures should be examined.

During the last 110 years, the coasts of Orissa, Andhra Pradesh, Gujarat and Maharashtra were hit by 102, 73, 21 and 6 cyclones, respectively. Extremely violent winds and heavy rains associated with tropical cyclones led to major floods, storm tides (combination of storm surge and astronomical tides) and coastal inundation. In the case of the May 1990 cyclone in Andhra Pradesh, the total loss of public and private properties was estimated as $480 million, while the estimated economic loss due to the 1999 Orissa super-cyclone was $2.5 billion. (Table 17 in Annex 1 presents a list of 34 largest cyclones that made landfall in India over the last century.)

The history of devastating seismic events has been no less frequent. A large part of continental India is prone to shallow earthquakes of magnitudes (M) of 5.0 or more on the Richter scale. Giant earthquakes of M > 7.5 have occurred in Kutch, the Andaman islands and the Himalayas. The largest earthquake in India, of 8.7 magnitude, took place in the Shillong Plateau in 1897. The extremely high intensity of this quake and the 1950 quake of M 8.6 in Sadiya region led to serious consequences. Rivers changed their course, ground elevations were permanently altered and huge rocks were thrown high up in the air. The most recent massive earthquake, measuring 6.9 on the Richter scale, struck Bhuj in Gujarat on January 26, 2001, and is conservatively estimated by the World Bank to have caused property losses (public and private) of $2.1 billion, entailing a reconstruction cost of $2.4 billion. Table 18 in Annex 1 has been complied from various sources and presents a list of some of the most damaging earthquakes in India.[38]

Although perhaps not as catastrophic as cyclones and earthquakes in terms of loss of life, floods are India's most frequent peril and cause large economic damage. Occurring almost annually in peninsular India, floods are caused by inland rainfall, rivers in flood plains and storm surges along the coast. Average annual rainfall in India is approximately 115 mm; almost 80% of the rain falls during the south-west monsoon which lasts from June to September. Tropical cyclone storms which occur during the pre and post monsoon periods during the months of May, October, November and December also bring heavy rainfall in short durations of 1-2 days. Although high, the average rainfall numbers are somewhat misleading due to a considerable variation in seasonal occurrence and spatial distribution of the rainfall. An analysis of national damage figures since 1953 shows that on average every year, floods affect about 7.5 million hectares and cause losses of over US$200 million (in real terms) in India. The loss includes damages to an average of 1.17 million houses, amounting to a direct loss of US$28 million, and a loss to public utilities of US$78 million. In 1988, the losses amounted to nearly a billion dollars

[37] All factual findings presented in this chapter are the result of a detailed risk management study conducted by RMSI, an Indian subsidiary of RMS, an international risk modeling consultancy, retained for this task.

[38] Major sources: I) Report of the expert group on Natural Disaster Prevention, Preparedness & Mitigation having bearing on Housing and Related Infrastructure – Part I, 1998; II) GSI, Seismotectonic Atlas of India & its Environs, 2000, Calcutta.

and in the 1978 floods, 3.5 million houses were damaged. A summary of flood losses between 1953-2001 is given in Table 19, Annex 1.

Selection of states and perils - Given the above described exposures of the country to natural disasters, the goal of the study was to analyze and quantify the impact of historical and probable future natural catastrophes on four States that suffered extensively from natural disasters in the recent past. As a result, Andhra Pradesh, Gujarat, Orissa and Maharashtra were selected as case studies. The study's key major objectives were to:

- Create a reasonably comprehensive exposure database for residential buildings and public infrastructure.
- Assess the nature of the hazards affecting the region, measure the exposures and vulnerability of districts/ blocks in the region to catastrophic shocks, and construct hazard maps based on the severity and frequency of hazards involved.[39]
- Develop an "actuarially sound" flexible loss model that can be used for catastrophe risk management at the state level.

The selected state and perils combinations are listed in Table 7.

Table 7: Modeling Scope of State and Peril Combination

	Andhra Pradesh	Gujarat	Maharashtra	Orissa
Cyclone	X	X		X
Earthquake		X	X	
Flood	X	X		X

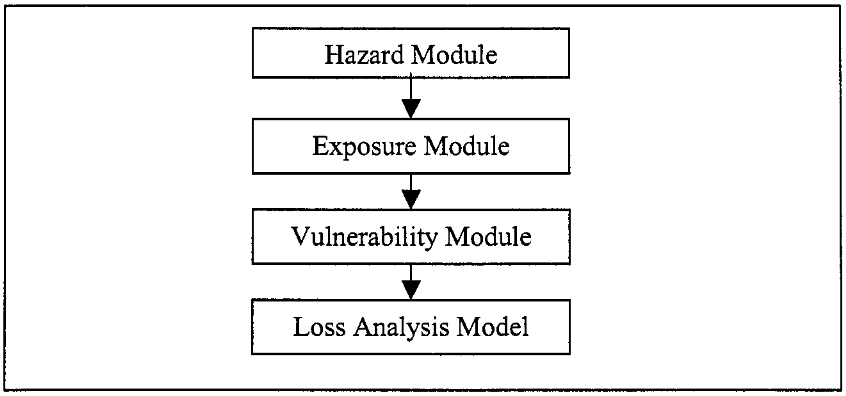
Note: "X" means included in the modeling scope.

Furthermore, due to the limited availability of data, the scope of the modeling with regard to potential losses was limited to: public infrastructure (consisting of educational, medical building, roads and bridges) and housing (residential dwellings). Government buildings, utilities, minor irrigation systems and commercial/industrial property are not included in the study and this translates into lower damage estimates than would be expected in practice.

Methodology - To arrive at probabilistic loss estimates, stochastic events from the characteristics of historical events were generated using simulation techniques. The simulations were carried out on occurrence parameters of the peril and the probability of occurrence of all events likely to cause damage to assets. The occurrence parameters in case of an earthquake are location, magnitude and depth, and in case of a cyclone are central pressure, forward velocity and direction of landfall. The generated set of stochastic events was then used in four modules of the probabilistic risk model, as shown in Figure 2. These modules are explained in brief below.

[39] For the purpose of the study each state was divided into several blocks of a fixed size.

Figure 2: The Probabilistic Risk Model



Hazard module: Once the parameters of each event in a stochastic set are defined, this module can analyze the intensity at a location once an event in the stochastic set has occurred. In earthquakes, the intensity of ground shaking is represented as MMI, and in the case of cyclones the unit is Peak Gust to measure wind speed. This module models the attenuation/degradation of the event from its location to the site under consideration and evaluates the propensity of local site conditions to either amplify or reduce the impact. The potential intensities of the three selected hazards: cyclone, earthquake, and flood, were assessed in separate hazard modules, which are discussed in Appendix III.

Exposure model: The exposure values of "assets at risk" at block level for the four states were estimated either from available secondary data sources or were derived from the distribution of population at the district or state level. Based on this data, the module then computes the value for all types of exposures as a product of multiplication of the area of total building inventory and the average replacement cost per unit of inventory.

Vulnerability module: The model quantifies the damage caused to each asset class by the intensity of a given event at a site. The development of asset classification is based on a combination of construction material, construction type (for example a wall and roof combination), building usage, number of stories and age. Estimation of damage is measured in terms of a *mean damage ratio* (MDR). The MDR is defined as the ratio of the repair cost to the replacement cost of the structure. The curve that relates the MDR to the peak gust or intensity of ground shaking at the site is called a *vulnerability function.* The study has developed vulnerability functions for different asset classes and perils.

Loss analysis module: To calculate losses, the damage ratio derived in the vulnerability module is translated into dollar loss by multiplying the damage ratio by the value at risk. This is done for each asset class at each location. Losses are then aggregated at block, district, or state level as required.

Loss estimates - The quantification of risk for the four selected states is the key objective of this risk assessment. The study yielded estimates of *average annual loss* (AAL) with standard deviation and of *probable maximum loss* (PML). Further outputs include *loss exceeding probability curves* (OEP/AEP) and the *pure risk premium* (PRP). It is worth mentioning however that due to the stochastic nature of risk modeling undertaken for the purposes of this research and significant data limitations, all estimates of risk exposures produced by this work are likely to suffer to a greater or lesser degree from statistical uncertainty, a factor to be considered in making policy decisions.

Average annual loss: Average annual loss (AAL) is the expected loss per year when averaged over a very long period. Computationally, AAL is the summation of products of event losses and event probabilities of occurrence for all events in the *event loss table* (ELT). The events are an exhaustive list affecting the location/ region under consideration generated by stochastic modeling. In probabilistic terms AAL is a mathematical expectation and broadly represents the Arrow Lind annual cost that would be budgeted for in a large and well diversified economy.

The AALs expected from future events are presented exhaustively in technical annexes of the main study by district, by peril and by asset class for each of the four states. Table 8 presents AAL summaries for the four states; tables 24 and 25 in Annex II present AAL summaries along with standard deviation (SD). Andhra Pradesh suffers the highest onging losses followed by Gujarat, Orissa and Maharashtra. Maharashtra suffers far lower losses despite having the highest exposed value when compared to other three states. Following the trends in the exposed values, housing accounts for most of the losses in all four states.

Table 8: Average annual loss summary

State	**All perils** (US$ Million)
Andhra Pradesh	82.9
Gujarat	64.9
Maharashtra	2.8
Orissa	43.2

Probable maximum loss: The concept of probable maximum loss (PML) is commonly used by insurance professionals as a measure of loss severity. Typically expressed as a percentage of value, PML is not ordinarily the "maximum possible loss," which is the worst possible scenario and which would, in many cases, be 100 percent of the property replacement value. Although actual losses can often exceed the PML estimates, they provide useful statistical approximations of underlying risk exposures. Stochastic catastrophe risk models, including the one used in this study, are now available in the marketplace to define and compute the PML. For the purposes of this study the PML is defined as the largest likely loss to housing and infrastructure in a given state from all perils corresponding to an event with a 150-year return period. Under this definition, the annual probability of losses from any single catastrophic event exceeding the given PML estimate would be equal 0.66 percent.

Although various definitions of PML are available for earthquake risk, there is little information on hurricane. A.M. Best, a leading insurance rating agency, considers a hurricane PML corresponding to 100-year return period (and an earthquake PML of 250-year return period) in its capital adequacy evaluation.[40] The American Society of Civil Engineers standard recommends a 500-year wind speed for the ultimate load design of buildings and structures.[41]

[40] Dunleavy (1998) (http://www.casact.org/coneduc/specsem/98catast/dunleavey.ppt).
[41] ASCE (1998).

In the case of flood risk, the PML evaluation involves a 3-step process: first, estimate probable maximum precipitation (PMP); second, compute probable maximum flood (PMF); and third, determine PML corresponding to PMF. The PMF is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.[42] The PMF is calculated from the PMP. The methodology adopted for flood modeling in the present study takes historical flood discharges at a particular gauging station as the input and the starting point. Under this approach it is not possible to estimate PMP and then compute PMF.

The PML corresponding to a 150-year return period is given in Table 26 by state, by asset class and by peril, and is summarized below in Table 9. Again, similarly to the AAL estimates, housing accounts for most of the loss.

Table 9: Probable Maximum Loss Summary (US$ Million)

State	Peril	Combined assets
Andhra Pradesh	All Perils	921
Gujarat	All Perils	1,009
Maharashtra	Earthquake	59
Orissa	All Perils	479

Pure risk premium: In insurance literature, pure risk premium is defined as the portion of insurance rate or premium intended to pay for insured loss under the insurance policy, for the cost of repairing or rebuilding the damaged property. It does not include adjusting for expenses, underwriting costs, profit, other contingencies, and inflation, which insurers add to the pure risk premium to obtain a final rate. Risk models are often used to quantify pure risk premiums for insured perils. To normalize, risk modelers consider pure risk premium as AAL per thousand dollars of exposed value. For modelers, the major advantage of pure risk premium over AAL is that it can be compared across perils, coverages, or geographic areas and useful conclusions can be drawn for validating the models. PRP eliminates the effect of differences in exposed values between comparables and thus simplifies comparisons. Tables 10 and 11 contain summaries of PRP by state, peril and asset class in units per thousand.

[42] U.S. Army Corps of Engineers Manual (1997).

Table 10: Pure Risk Premium Summary – (i)

State	Combined assets – per mille			
	All perils	Cyclone	Earthquake	Flood
AP	1.91	1.41	-	0.50
GJ	1.37	0.55	0.36	0.46
MR	0.04	-	0.04	-
OR	2.64	2.11	-	0.53

Table 11: Pure Risk Premium Summary – (ii)

State	Housing- per mille				Public infrastructure – per mille			
	All perils	Cyclone	Earthquake	Flood	All perils	Cyclone	Earthquake	Flood
AP	2.11	1.55	-	0.57	1.52	1.15	-	0.37
GJ	1.83	0.76	0.52	0.56	0.65	0.22	0.11	0.32
MR	0.05	-	0.05	-	0.01	-	0.01	-
OR	3.79	3.22	-	0.57	1.64	1.15	-	0.49

While in the case of absolute AAL estimates, Orissa did not figure prominently due to a relatively low asset base at risk compared to the larger states, once a ratio of AAL to value of assets at risk is computed, the state ends up with the highest PRP of 3.96 per mille among all four states. Andhra Pradesh comes as a close second with its pure risk premium of 3.83 per mille. Again, housing exposures to natural disasters in all four states account for most of the risk.

Loss exceedance curves: Aggregate exceeding probability (AEP) and occurrence exceeding probability (OEP) curves are the other two powerful statistical tools for quantifying the severity of losses. Exceeding probability curves are cumulative distributions showing the probability that losses from a single catastrophic event will exceed a certain monetary threshold. What these losses represent is key to understanding the difference between the AEP and the OEP curves.

The AEP curve deals with aggregate annual dollar losses (vs. dollar losses per event in case of the OEP curve). It shows the probability that aggregate losses per year (i.e., the sum of all losses from all annual events) would exceed a certain threshold. The OEP curve deals with losses from individual events occurring in a given year. It shows the annual probability of losses from at least one occurrence exceeding a certain monetary value. This distinction between the two AEP and OEP curves is crucial. Since OEP is the cumulative distribution for the largest occurrence in a year, it can be used to analyze occurrence based situations. For example, one can calculate the probability of activating and exhausting occurrence based contracts such as a policy or reinsurance quota share treaty using the OEP curves. In addition, the OEP curve can provide statistical information on single event covers.

Loss EP curves (AEP and OEP) and loss return period tables by peril and by asset class are provided in Annexes of the main study for each of four states. Tables 12 and 13 present return period losses derived from the AEP curves for all public and private assets combined. For instance, by reading the AEP loss exceedance data for Andhra Pradesh, one can infer that there is a 1 percent chance that losses from all natural perils in a given year will exceed US$ 811 million.

As larger catastrophic events occur rather infrequently, the probability of events causing losses in excess of US$ 1.43 billion is only 0.1 percent, which roughly corresponds to a 1,000 year event.

Table 12: Return Period Losses for Combined Assets (US$ Million) – (i)

AEP	RP	Andhra Pradesh			Orissa		
	years	All perils	Cyclone	Flood	All perils	Cyclone	Flood
0.2	5	111	68	48	68	52	8
0.1	10	203	155	74	111	93	18
0.04	25	411	389	115	171	145	72
0.02	50	595	582	147	254	239	96
0.01	100	812	780	176	380	368	115
0.004	250	1,047	1,049	213	659	671	142
0.002	500	1,214	1,196	239	889	862	164
0.001	1000	1,432	1,328	262	1,055	1,053	170
0.0002	5000	1,691	1,600	0	1,301	1,276	
0.0001	10000	1,885	1,643	0	1,458	1,306	

Source: RMS Delhi

Table 13: Return Period Losses for Combined Assets (US$ Million) – (ii)

AEP	RP	Gujarat				Maharashtra
	years	All perils	Cyclone	Earthquake	Flood	Earthquake
0.2	5	81	9	0	34	
0.1	10	155	72	0	57	2
0.04	25	289	176	41	119	11
0.02	50	465	292	151	156	24
0.01	100	767	428	431	197	43
0.004	250	1,427	659	1,197	255	83
0.002	500	1,997	873	1,742	287	132
0.001	1000	2,436	1,183	2,271	308	230
0.0002	5000	3,126	2,013	2,946		1,244
0.0001	10000	3,283	2,125	3,102		1,553

Source: RMS Delhi

Despite the limitations mentioned earlier this study presents the first comprehensive effort to quantify the aggregate catastrophic risk exposures in four Indian states. The results of risk modeling displayed in this chapter confirm that three out of four selected states have large exposures to natural disasters which warrant active risk management. Table 14 below attempts to summarize the findings of the study by ranking the four states by their risk exposures for each of the above described risk measures.

Table 14: Rankings of Four States in Terms of Their Risk Exposures

State	AAL US$ MM	AAL Rank	150 Year PML US$ MM	150 Year PML %	PML Rank	Pure risk premium per mille	Pure risk premium Rank
Andhra Pradesh	82.9	1	921.2	2.12	3	3.64	2
Orissa	43.2	3	479.1	3.18	1	3.96	1
Gujarat	64.9	2	1,009.4	2.13	2	1.97	3
Maharashtra	2.8	4	58.6	0.08	4	0.04	4

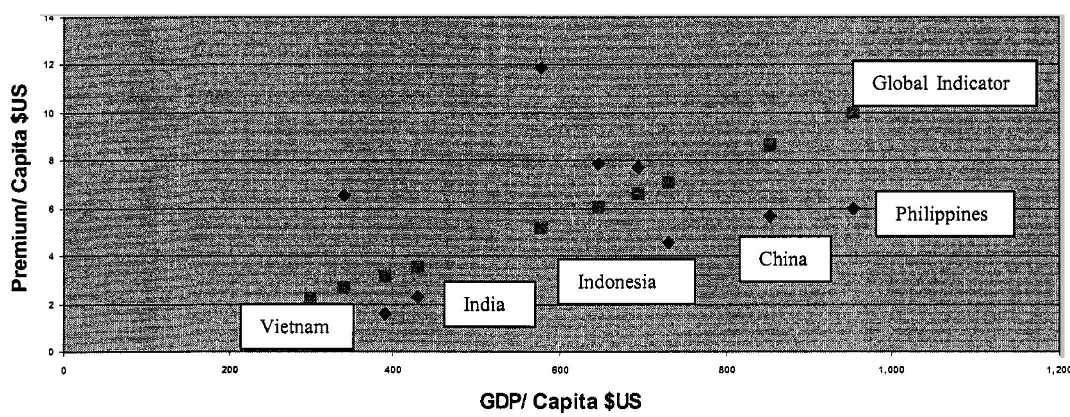
While in terms of pure risk premium, Orissa and Andhra Pradesh are most vulnerable to natural disasters, when such relative measures of risk as PML and PRP are considered, Orissa due to its highly concentrated risk exposures to severe although rare earthquakes and coastal cyclones clearly appears to be in the worst position of the selected states. Gujarat is the second worst in terms of PML, followed by Andhra Pradesh. Maharashtra's exposures are found to be rather moderate by any measure.

IV India's Insurance Market Is Undeveloped And Intervention Is Required To Increase Penetration And Maintain Adequate Capacity

In most industrial countries, between 30% and 60% of all direct and some indirect catastrophe losses are typically funded through private insurance and reinsurance markets. Typically insurers cover private sector property (including housing) and lost profits, although in some cases the public sector also buys insurance (see Annex VIII for an industrial country consumer's perspective on catastrophe insurance). This is sometimes supplemented by state mandated catastrophe pools, supported by contingent public funding when the potential loss is large relative to the premium pool that can be generated in the jurisdiction concerned (see Appendix I). In most cases such catastrophe pools are closely integrated with the domestic insurance market, which typically has a penetration in excess of 90% of households. A major driving force for the establishment of such pools has been the need to protect the balance sheets of mortgage providers (Jaffee and Russell (1997)).

General insurance consumption in India is low (Chart 4), even when compared to a trend line based on international norms, although it is not out of alignment with a number of other Asian countries in its peer group (as measured by GDP per capita). This is despite having had an active insurance sector for well over a century. Countries below the trend line have historically been subject to either strong central government control or have had restricted foreign entry into the insurance and/or reinsurance sectors, while those above the line have had active and open insurance markets.

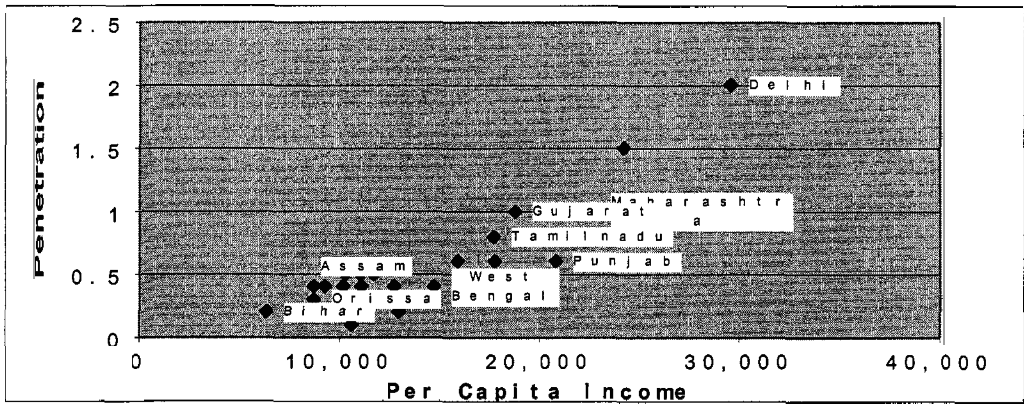
Chart 4: General Insurance Consumption - Low Income Countries



While India under-performs against its overall peer group as measured by GDP per capita, an examination of insurance penetration by state shows that an income effect is at work within the country (Chart 5): [43]

[43] Underlying data appears in Annex II.

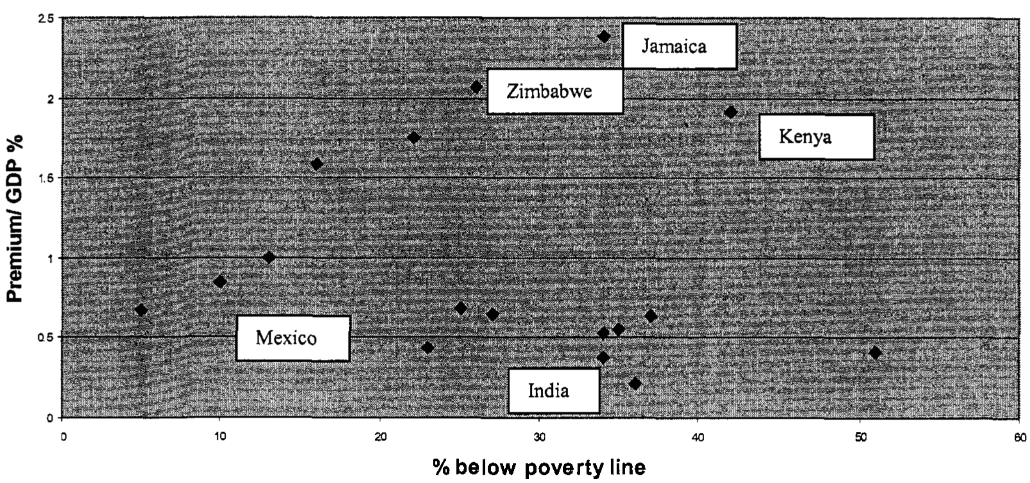
Chart 5: Penetration vs. Per Capita Income, 1998-1999



Source*:* Prepared from data in Annex II

While it could be argued that the shifting down of the Indian insurance consumption curve arises from income distribution and in particular the high level of poverty in the country, a re-charting of developing markets according to poverty level shows no apparent causality and indicates that some country specific factors are at work (Chart 6).

Chart 6: Poverty impact on Insurance Penetration

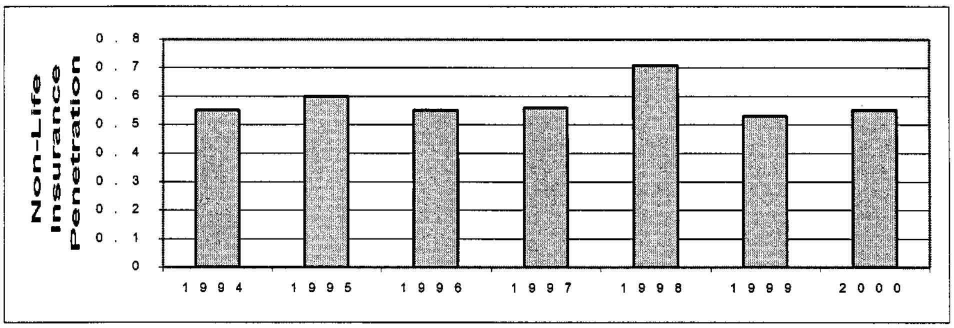


Source: CIRE study

To explore the issues specific to India it is useful to consider supply and demand issues separately.

Supply Issues – The relatively low level of insurance sector development in India has to some extent been attributed to the fact that the non-life insurance industry in India, consisting of 107 domestic and international insurers, was nationalized in 1972, which eventually led to a loss of service standards and entrepreneurial drive.[44] Upon nationalization the industry was consolidated into the four large regional government owned insurers (based in Mumbai, Delhi, Chennai and Calcutta), with GIC as the holding company and national supplier of supplementary capacity through proportional reinsurance. The negative developmental implications of this oligopoly were ultimately recognized, and in 1994 the Malhotra Committee recommended that private sector competition be reintroduced. After some resistance the relevant legislation was passed in 1999 and 2000. The need for reform became manifest after the Commission reported; the non-life sector showed no growth in penetration (Chart 7), even under the threat of competition:

Chart 7: Non-Life Insurance Penetration in India, 1994-2000 [45]



Sources: Swiss Re., SIGMA.

The reforms have included the setting up of a modern and well resourced supervisor, the Insurance Regulatory and Development Authority (IRDA), under the control of a senior government official. The IRDA has since carefully and successfully guided the re-opening of the sector to market competition. Key elements of the liberalization strategy have included the following requirements: that a substantive Indian enterprise hold at least 74% of the equity in a new insurer; that minimum capital be set at a relatively high level by international standards (Rs 100 Crores or approximately US$21 million); only a limited number of highly reputable international players would initially be allowed to enter the market; the existing pricing tariff regime would be maintained for a period; and ensuring that the actuarial profession has a key role to play and should be developed accordingly. In addition, steps were taken to expand and energize distribution. As the market matures, some of these controls will be gradually relaxed. This has already begun with the recent splitting up of the GIC group and significant policy moves towards removal of the tariff system are expected in the next two years.

Initially, four privately owned general insurers were granted entry and this number has recently expanded to eight, all with foreign partners, thus adding Rs 800 crores (US$ 168 million) of capital or approximately US$400 million of premium underwriting capacity to the market.[46] The first full year of business under the market model was 2002/3, and after nine months of business the new players had booked written premiums of Rs 965 crores (US$ 203 million) or 9.3 % of

[44] IRDA Annual Report, 2000-2001, page 2.
[45] Penetration is premium as a proportion of GDP and is a broad measure of consumption preference.
[46] Minimum capital for a new direct non life insurer is Rs 100 crores.

the market. This in part reflects the transfer of the industrial and fire accounts of the Indian partners in the joint ventures to their associated insurers. Overall, there remains capacity for further growth of the private players. However, establishment expenses and market growth may, at some point, limit their scope to acquire more market share unless they bring in additional capital. The four government owned insurers are writing very conservative premium volumes given their available capital and surplus (Table 15), and have substantial scope to grow in real terms.

Direct capacity is further increased by the fact that all insurers are required to cede 20% of their business to GIC (subject to limits for fire, engineering and energy risks), which is transforming itself into a professional reinsurer under the liberalized industry structure initiated in 2002. The capital resources of GIC's stand alone operation were approximately Rs 4,000 crores (US$ 842.10 million) at the end of the 2001 financial year. The IRDA has also suggested that insurers establish catastrophe reserves varying from 0.5% to 5% of relevant net premiums, which will bring India into closer alignment with other catastrophe prone countries. Thus in a direct writing sense aggregate premium capacity is unlikely to be an issue in the foreseeable future, even if India achieves its potential or greater according to international norms (see Appendix II).

Table 15: Capacity Utilization, 2002 (Rs Crore)

	New India	United	Oriental	National	Total US$ bill.
Capital and capital reserves	5920	2506	2429	2748	2.86
Gross Written Premium	4198	2781	2499	2439	2.51
Net Written Premium	3068	2045	1818	1813	1.84
Potential Net Premium on conservative premium gearing of 2 times capital	11840	5012	4858	5496	5.73
Estimated free premium capacity %	*80.6*	*67.5*	*66.1*	*71.8*	*67.8*

Source: IRDA 2nd Annual Report (2001-2002).

Despite the clear underutilization of capacity relative to normal risks (Table 15), there is inadequate capacity to cover peak industrial and infrastructure risks and possibly some catastrophic loss aggregating events such as a windstorm in Mumbai or an earthquake in Delhi. The largest general insurer retains Rs 10 crores (US$2 million) of catastrophe exposure and buys excess of loss coverage up to a limit of Rs 260 crores (US$57 million). There is an umbrella cover of Rs 100 crores (US$22 million) on top of this. This reinsurance schedule is probably more than adequate given the current take up rate of disaster insurance in India. The average PML ratio applied of 30% is very high for a well diversified portfolio, and reinsurers no doubt reflect the lack of accurate accumulation data in their pricing, pointing to the probability that India is currently overpaying for reinsurance, and has some latent capacity which would be released if better data were available.

The need to access external reinsurance markets is normal for the great majority of countries in the world, particularly as penetration of general insurance grows. According to some alternative estimates the Bhuj earthquake generated insurable direct losses of up to Rs 21,000 crores (US$4.4 billion), although actual insured losses amounted to only Rs 750 crores (US$16 million) because of low levels of insurance penetration.[47] In addition, there are individual peak risks (known as mega risks in India), such as the Reliance petrochemical plants in Jamnagar, which have total sums insured that are currently a multiple of Indian aggregate non-life premiums and have an earthquake PML (75% of total exposed value, compared to the more typical Indian figure of 30%), which at least approximates the size of the national premium pool.[48] GIC rightly limits itself to a retained exposure of Rs 50 crores (US$11 million) for industrial fire and Rs 90 crores (US$20 million) for advance loss of profits (ALOP) and buys Rs 850 crores (US$185 million) of excess loss cover, with Rs 100 crores (US$22 million) on top. Earthquake is an optional add on coverage, as opposed to RSMD[49] which is covered by default. Regardless of packaging the take up of additional coverages over and above basic fire and engineering wordings has been disappointingly low. After the Bhuj event the President of the Bengal Chamber of Commerce was quoted as pointing out that despite reasonable pricing "owners of large buildings in Gujarat excluded both these policies and only an estimated five percent of households with fire policy paid extra for earthquake."[50]

The nexus between industry structure and capacity is subtle for general insurance and India's strategy to date of attracting enough serious players to ensure adequate competition while avoiding fragmentation appears to be appropriate. Studies carried out to date appear to demonstrate that industry fragmentation actually lowers domestic risk bearing capacity while foreign entry increases it. [51] Despite this, and as personal lines and small business property insurance increase in popularity, India will need to ensure that it has a sophisticated and competitive capacity to deal with international risk transfer markets. This points to allowing a small number of additional qualified reinsurance intermediaries into the local market to add technology and to provide a healthy level of competition. A number of countries, including Turkey and China, have withdrawn mandatory cessions to their national reinsurers on a phased basis, and this may become appropriate in India at some time in the future.

Where the private sector cannot cover a risk the Indian government has shown a willingness to step in. After the events of September 2001, reinsurance cover largely ceased to be available for terrorism cover in India and this coverage was delinked from the basic fire wording. An initial alternative considered involved a surcharge on premiums which would build a reserve, with the government providing initial reinsurance, to be repaid over time by the insurers in the event of a claim. This was to be backed by a formal insurer catastrophe reserving system, with tax incentives. In the event, the industry asked that the levy be treated as premium with central pooling to be administered by GIC.[52]

Even if reinsurance is available, high prices are another potential stumbling block to increasing catastrophe reinsurance penetration. One way of lowering reinsurance pricing is to provide good information about catastrophe event risk. In this regard India is currently not well served, despite having a leading edge intellectual and technical capacity to do the necessary applied

---

[47] GIC showed an estimate of Rs 361 crores (US$ 78 million) as its loss from Bhuj in its 29th annual report (2000-2001). By contrast Hurricane Andrew in Florida in 1992 resulted in an insured loss of US$17.0 billion against an estimated total loss of US$30.0 billion, much of which was retained by direct insurers.

[48] PML is the level of risk up to which the insured wishes to seek coverage given the relevant loss exceedance curve.

[49] Riot, strike and malicious damage cover. This is a required coverage if terrorism cover is provided.

[50] Business Line, April 23, 2001.

[51] Outreville (2000).

[52] IRDA 2nd Report 2001-2002, page 40.

research and a huge but fragmented database. Munich Re recently[53] presented a paper on catastrophe potential in India and this appears to have acted as a catalyst for a more active debate. In particular, it appears that there is a need to do more physical modeling of the earthquake process on the subcontinent, to review earthquake zones and to allow for soil type, particularly in the large cities on the Ganges flood plain.[54] In this regard, the recent decision to move to a single country wide solidarity based earthquake premium loading of 10p per Rs1000 for smaller property risks potentially limits the scope to encourage mitigation and to ensure a contribution to the Indian disaster premium pool from those in less earthquake prone areas. When a similar pure solidarity approach was attempted in Turkey it became very clear very quickly that people in general are aware of relative levels of risk and that those in areas of low seismicity had a limited willingness to subsidize their countrymen in high risk zones. The 15 risk zone premium structure finally adopted by TCIP now provides for relative risk levels reflecting a property's location and construction quality.

Other supply constraints in India, and poor service in particular, will presumably reduce in importance as competition forces better performance; however it is likely to be on the claims handling side that the big four will ultimately rise or fall. Anecdotal evidence, backed by GIC's own published productivity and establishment data, point to very slow and potentially bureaucratic claims handling processes, which favor the insurer in the event of dispute.[55] A key problem in this regard appears to be a hierarchical approval process and an unwillingness on the part of front line officials to exercise discretion, even when the relevant authority has been delegated.[56] The insurance supervisor is now taking vigorous action to redress the balance between insurers and claimants, including the establishment of various recourse mechanisms for consumers.

Possibly the most important supply innovation will be the opening up of new distribution systems and the creation of a more professional and well remunerated sales force. Commissions for household and small business coverage have historically been 10%, although these were increased to 15% as an incentive to agents to market to the rural sector and certain other under-serviced communities. Other distribution channels being explored include brokers (a substantial number of licenses have already been issued, including one JV involving an international broker), bancassurance and direct selling using the internet and other electronic media.[57] These are highly desirable reforms as the sales and distribution system has been handicapped by a lack of incentives and hence entrepreneurship.[58] However it seems unlikely that any of these mechanisms will efficiently or effectively reach the less affluent sections of the population, particularly the poor, although the government has mandated that the new players should underwrite certain minimum proportions of business in the rural and "social" sectors as follows:

[53] Institute of Administration Natural Disasters Conference, Delhi, February 2002.
[54] K. Mishra (2002).
[55] CIRE estimates that approximately 45% of claims outstanding at any one time have been pending for at least one year, and 23% have been pending for at least three years.
[56] The Comptroller and Auditor General of India was reported as questioning the flexibility that insurers showed in settling clams after the Bhuj earthquake, but evidently accepted that special circumstances deserve special approaches.
[57] Banks may enter the market as corporate agents, strategic investors or promoters.
[58] The four state owned insurers announced in March 2003 that they have reduced their traditional marketing force by 32% through a voluntary retirement scheme.

Rural Sector (of gross written premium):

First Year	2%
Second Year	3%
Third Year	5%

Social Sector (lives insured):

First Year	5,000
Second year	7,500
Third year	10,000
Fourth year	15,000
Fifth year	20,000

Performance against these targets has been mixed, with the private sector players generally performing adequately, although two insurers have received notices relevant to the social sector. The definition of rural sector was recently modified to include townships where 25% of the male population is engaged in farming (rather than 75%) and one of the new insurers appears to be making some inroads into this market. The performance of the large state insurers has been "tepid" and the IRDA has had discussions with the relevant management.[59] Despite these mixed results, the delivery of risk management products to the rural and social sectors is a legitimate objective and mechanisms need to be found to effect this result. The key issue appears to be the creation of special intermediaries between the formal sector and the target group, which can deal with moral hazard, design and price appropriate products and provide relevant education on risk management at the level of the household and individual economic activity. This is an area undergoing a rapid evolution around the developing world and a number of the most advanced experiments are being carried out in India.[60] Early results indicate that insurance can be sold to the poor as part of other service offerings, but that as a stand alone product it suffers from lack of understanding and its inherently intangible nature. If a working model can be found there may be arguments for reducing the minimum capital and other relevant requirements for mutual insurers, as has been the case under EU law, subject to minimum membership and other relevant prudential and governance requirements.

Another mechanism that has been developed in India is the state level insurance funds, which are regulated by IRDA and come under the provisions of the federal insurance law. Their retentions are small and most risk is transferred to one or more of the big four non- life insurers. In Gujurat, for example, the Government Insurance Fund insures government infrastructure and provides coverage for death and disability under group personal accident policies for the socially disadvantaged.[61] The five groups covered are small and marginal farmers, police personnel, people below the poverty line, landless laborers and college students. Premiums are paid by the relevant government department, with the Commissioner of Rural Development being responsible for those below the poverty line.

The final supply issue is pricing, which is subject to a tariff for all major classes (75% of all business) and has historically been distorted by a heavy cross subsidy from property classes to motor insurance, and to motor third party liability insurance in particular. There have been

[59] IRDA 2nd Annual Report, page 6.
[60] See for example the Self Employed Women's Association insurance model.
[61] In practice only state and municipal buses, power generating assets and assets of some state enterprises are covered in Gujarat and the situation is likely to be similar in other states

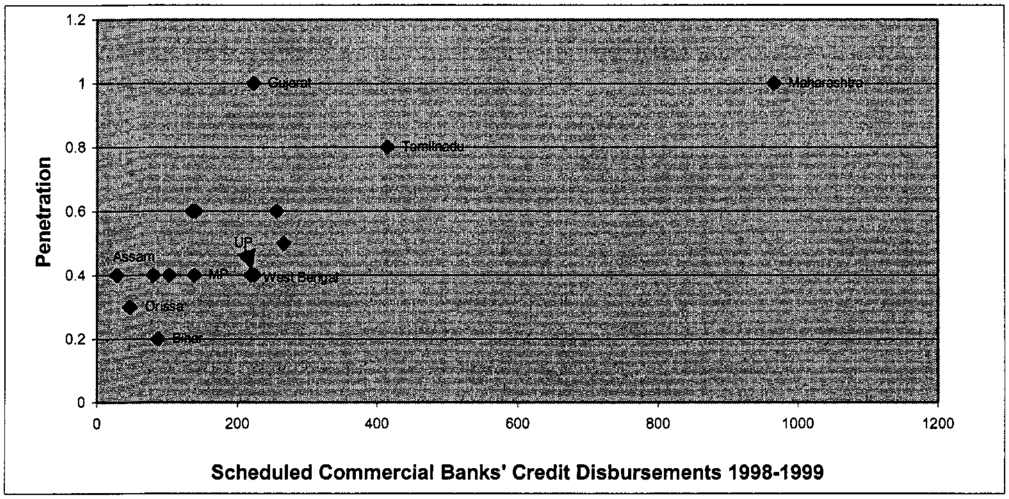
numerous attempts to date by the rate setting body (TAC) to revert to actuarially sound pricing or at least a less egregious transfer, but without success because of the lobbying efforts of the haulage industry. In the interim, fire rates have been reduced three times based on experience, but continue to produce relatively good results for the underwriters. Recently, the insurance supervisor, as part of the market liberalization package and recognizing increased competition, has announced that tariffs, starting with the commercial motor sector, will be phased out. Market based pricing should lead to lower and more risk sensitive property rates over time, ensure that databases become aligned with the key rating factors, and increase the scope to add catastrophe coverages.

Demand Issues – There is a price at which insurance ceases to be attractive, even if it is fully understood and is seen as an intrinsically attractive service by the risk averse consumer (see Appendix II). The price established by the insurer includes the estimated expected loss, expense loadings and allowances for the cost of the capital backing the solvency of the insurer. This equation tends to work best when the pure risk component is large relative to the fixed costs of the insurance enterprise, including its distribution system, and there is a degree of confidence about the risk pricing model being used. This in turn implies good and credible data, limited scope for moral hazard or fraudulent behavior and a relatively large customer base.[62] The equation tends to break down for sections of society that are difficult or expensive to reach, do not understand or trust formal sector financial institutions and have incentives to influence the probability or quantum of a claim. Thus it seems likely that for parts of Indian society the formal sector insurers cannot directly provide an insurance product at an acceptable price, at least without subsidy.

However there are large sections of Indian society for which a fair premium would, by international standards, be acceptable in term of their income levels, and which have already shown a propensity to purchase life insurance. It is estimated that personal lines insurance (including compulsory motor) is between 4% and 6% of total premium income, and the Bhuj earthquake pointed to less than 2% of domestic residences being insured in what is a relatively industrialized state. Possibly the most important factor underlying this low penetration is a lack of knowledge and understanding of the insurance mechanism, which in turn tends to be a function of education and awareness. CIRE reports that "except for policies which are purchased due to government mandate (e.g. motor third party liability insurance, public liability insurance etc.) or insistence by lending institutions such as banks or housing societies, customers are largely unaware of the existence of non-life insurance policies." The correlation with credit generation in particular is quite noticeable (Chart 8).

[62] Credible data is largely a function of the number of claims generated by a rating class. Typically a minimum of 1,000 claims are required before a premium rate can be determined with a degree of confidence, for a personal lines rating category where the individual claims distribution is not highly skewed.

Chart 8: Insurance Penetration and Credit Disbursement, 1998- 1999



Source: CIRE

In this context, the importance of effective public education about the financial consequences of catastrophe risk exposures and the insurance products available to address them should not be underestimated. International experience demonstrates convincingly that effective public awareness campaigns conducted through mass media and education channels can dramatically improve the public perception of government sponsored insurance programs and thus contribute to increasing insurance penetration. An excellent example of how an effective public information campaign can help to change public attitudes and boost insurance is the Turkish Catastrophe Insurance Pool (TCIP). Only three years after its launch, and despite the initial rather hostile attitude of the population to any government mandated insurance programs, the TCIP has managed to build nationwide acceptance of its insurance coverage. It has now become the most trusted name in the Turkish insurance market due to an active and creative ongoing public relations and mass education campaign, which, according to the TCIP's estimates, has enabled it to attract an additional 350,000 homeowners annually.

Another major issue for disaster related coverages is that precedent has been established for the provision of public funds for the reconstruction of the housing sector, creating a potential moral hazard and a lack of propensity to seek alternative insurance arrangements. In the case of Bhuj, housing reconstruction accounted for close to a half of estimated post disaster public sector reconstruction costs.[63] While some of these outlays may have financed post disaster relief and reconstructions needs for the poor and thus may be justified, it appears that those who could afford earthquake insurance also received funds which could have been better used elsewhere.

The ease of access to insurance, and hence its cost to potential consumers, may also be an issue. Anecdotal information points to a highly competitive market developing in the cities[64] and there may be opportunities for specialist rural community based insurers to emerge in India as has happened in a number of industrial countries with large agricultural sectors. These latter

[63] Lahiri et al. (2001), Table 9.
[64] There have been a number of tariff breaches in the last year, necessitating a 400% increase in the relevant fine.

organizations are often closely associated with farmers cooperatives and the main agricultural input suppliers, including credit providers.

Other factors that have been quoted as accounting for lack of demand include a fear of disclosing assets (partly a tax issue), a perceived lack of secure or negotiable property titles and an inefficient tort system (see earlier comments on claims management).

National catastrophe insurance programs require massive enrollment to achieve a balanced and well diversified portfolio of risk and affordable pricing for insureds, even at the most hazardous locations. That can be achieved either (i) by making catastrophe insurance coverage compulsory for all registered homeowners (perhaps, with some minor exceptions), or at least for those borrowing; or (ii) voluntarily, through active public education and mass marketing campaigns. While each country requires a unique solution, a key consideration is the tradeoff between achieving wide participation through compulsion and the creation of a public impression of catastrophe insurance premiums being a tax with consequent adverse effect on households' risk management behavior. In addition, the level of solidarity build in to the rating structure requires a tradeoff between simplicity, social equity and the encouragement of mitigation efforts.

V. Findings, Policy Options And Recommendations

Findings

The combination of an increasing incidence of natural disasters and the current approach to funding and applying post disaster relief and rehabilitation (which is being effected in the context of chronic revenue deficits) detracts from India's development program. More positively, significant progress has been made in some states over the last three years (and in the last 12 months at the national level) in building institutional capacity for disaster management. However this is fragmented and there appears to be no overriding and comprehensive catastrophe risk management framework in existence, although the central government has clearly evidenced a desire to move in this direction (see Tenth Planning Commission Report and Report of the High Powered Committee on Disaster Management). In particular, the current national approach to disaster management at the central and state levels suffers from a lack of institutional incentives and underplays the role of risk financing, including ex ante mechanisms such as catastrophe reinsurance and contingent credit facilities. As a result, the potential *funding gap* between damages sustained by the states and funds available from all sources to finance them in the aftermath of natural disasters has been increasing (Table 16).

Table 16: Catastrophe risk exposures as percentage of key economic flow measures in four selected states

State	150 Year PML[65] US$ MM	GSDP (%)	Tax Revenue (%)	Fiscal Deficit (%)
AP	921	3.3%	28.7%	61.5%
GJ	1,009	4.4%	43.7%	32.8%
MR	59	0.1%	1.1%	2.7%
OR	479	6.5%	41.9%	19.9%

The infrastructure of India is in danger of being significantly degraded as fiscal/ capability constraints limit capital expenditure options. The need for rapid emergency repairs post disaster affects the quality of work, and in one case (Gujarat after the recent earthquake) scarce public funds have been diverted to rebuild housing for self sufficient sections of the population. As financial assistance from the NCCF and CRF accounts for a small fraction of expected losses, reconstruction of destroyed or damaged infrastructure is funded by redirecting current budgets to the extent possible. Should current budgets prove inflexible, budgets from future years are used to fund the reconstruction at a future time. Such a process results in delayed and inadequate restoration of important assets, and consequently, reduced functionality and operating lives. Other consequences of current practices are heightened maintenance with attendant future costs, as well as increased vulnerability of the affected assets to future natural disasters. In addition planned capital projects necessary to support a growing economy will not be undertaken or will be deferred, prejudicing future economic growth.

[65] PML = Probable Maximum Loss for a 1-in-150 Year event (similar to the magnitude to the recent Gujaratj Earthquake).

These findings are supported by a detailed case study of two recent catastrophic events in AP, a sources and uses of funds analysis following the Bhuj (Gujarat) earthquake, as well as by more general fiscal statistics from other states. The mission team believes that most states are not financially prepared to deal with the consequences of severe catastrophic events and that a number of states would find it difficult to use funds even if they were made available.

Natural disasters, partly through the destruction or damage of life line infrastructure such as roads and clean water supply, increase the gap between the poor and other sections of society. This effect has already been well documented elsewhere, but a comprehensive approach to dealing with it has yet to be developed.[66] The current funding approach has unpredictable impacts on the poor, since the poor have few accumulated financial assets to rely upon following a catastrophe: even a slight decline in government assistance arising from reallocations of government budgets (for example reconstruction of houses for the non-poor) can leave the poor further behind. As many are dependent on the agriculture/horticulture sector, delays in rebuilding/restoration of rural infrastructure (such as roads, water supply and electricity) immediately affect those with no or limited other income and minimal consumption cushions.

Ongoing and effective mitigation is not encouraged by the current funding methods, except when donor funds are involved and the relevant donor makes this a conditionality. Mitigation has several meanings and there is a need to concentrate on those forms of mitigation which have the best demonstrable impact (building standards sufficient to at least save lives, early warning systems, etc.) and have credible ongoing funding sources that will ensure their sustainability. In light of the overall importance of reducing the country's risk exposures to natural disasters, serious thought should be given to the use of fiscal and institutional incentives to promote active risk reduction efforts at the local level.

The lack of institutional capacity at the local level to absorb donor funds following large natural disasters frequently results in the slower than expected utilization of external aid, as well as leakages and misuse of funding. These factors impair speedy economic recovery and reconstruction efforts. The problem is frequently exacerbated by the rigid and rather bureaucratic procurement and disbursement guidelines attached to the receipt of development and reconstruction aid. These guidelines require the creation of specialized project implementation agencies at the local level, along with specially trained staff that may be in short supply at the time of a disaster.

General insurance consumption in India is low, even when controlling for the level of economic development. There are numerically large sections of Indian society for which a fair premium would, by international standards, be acceptable in term of their income levels, and which have already shown a propensity to purchase life insurance.[67] However, it has been estimated that personal lines insurance (excluding compulsory motor) account for only 4% to 6% of total premium income, and the Bhuj earthquake pointed to less than 2% of domestic residences being insured in what is a relatively industrialized state. Despite a clear underutilization of local insurance capacity relative to normal risks, there is inadequate capacity

---

[66] See for example Bhatt, Natural Disasters as National Shocks to Poor and Development, World Bank, 1999 and ADB JFPR:IND 36029.

[67] It is estimated that approximately 7% (both rural and urban) of the Indian population fall into the "non- poor" categories (Deshpande (2003)).

to cover peak industrial and infrastructure risks, and possibly some catastrophic loss aggregating events such as a severe earthquake affecting Delhi, without resorting to international reinsurance markets. On the "positive" side, India is probably overpaying for reinsurance because of a lack of detailed risk accumulation data, and has some latent risk absorption capacity which would be released if better information were available.

In summary, the current funding approach to severe natural disasters in India involves a largely reactive response to each event. Some proactive efforts are now being made to reduce the future financial and human losses through mitigation (including land planning, improved building codes and construction practices) and disaster preparedness, but there has been limited scope for the design of ex ante funding programs which provide immediate funds for reconstruction. This is becoming an increasingly important policy issue as the adverse effects of natural disasters will almost certainly only become larger with increased population concentrations and concomitantly increasing concentrations of social and productive capital.

Having examined existing institutional arrangements for mitigation and risk financing at the central and state level and taking into account the potential funding gaps revealed by the in-depth risk assessments of four selected states, the mission team has developed a number of policy options and some specific recommendations.

Policy Options

Develop a Risk Financing Strategy as an Integral Part of National Disaster Management. Mitigation and risk financing are the two pillars of effective catastrophe risk management at the country and state level. In India government actions in risk reduction and prevention (commonly referred to as mitigation), should be augmented by a formal approach to risk financing. Such a risk financing strategy would consist of three parts. First, formal risk assessments at the state and the central levels; second, identification of funding gaps; and third, development of state and national risk management plans aimed at closing the identified funding gaps over time. Such risk management plans are likely to consist of a combination of mitigation and risk financing initiatives, which inter alia, could include vulnerability reduction programs, catastrophe insurance and access to a federally maintained contingent credit facility.

Introduce Fiscal Incentives for Active Risk Management at the State Level. The mission team believes that the size of identified funding gaps can partially be explained by a lack of institutional incentives for better risk management at the state level.[68] Currently, states rely on six main sources to fund relief and rehabilitation work in the aftermath of natural disasters: (i) funding from the state Calamity Relief Funds (CRF) to provide immediate relief to the victims of natural disasters and urgently restore life-line infrastructure; (ii) the National Calamity Contingency Fund (NCCF), which provides financing for expenditures by state governments in excess of balances available in their CRFs following particularly severe events; (iii) state annual capital budgets; (iv) reallocation of Plan funds, which can be used for reconstruction of damaged infrastructure; (v) contingency funds, including the Prime Minister's Relief Fund; and finally (vi) international and domestic donor funds, upon the occurrence of calamities of great magnitude.

[68] The level of post-disaster funding to the states is based largely on the size of disaster losses and the state economy. The current system does not provide incentive for those states that may have taken proactive steps in risk reducing measures.

For the purposes of our further analysis, we have grouped these funding sources into two funding categories:

(a) **Ex ante funding sources**, under which the amount of financing available for relief and rehabilitation is pre-arranged and possibly allocated prior to the occurrence of disasters. This presently consists of the CRFs and current capital budgets.
(b) **Ex post funding sources**, which provide funds in the aftermath of natural disasters. These sources include reallocation of planned funds from future capital budgets, central post-disaster assistance and donor funds. Overall, it appears that the States have little fiscal flexibility to pursue ex ante risk management initiatives that are not funded from external sources.[69]

To reduce the funding/capability gap and the vulnerability of infrastructure, the existing national system of post disaster financing could be redesigned to provide strong fiscal incentives for the states to adopt more proactive approaches to risk management. Such a "carrot" based approach to disaster risk management at the local level by the GOI would be consistent with best international practice available today in developed countries. Two cases in point are the U.S. Federal Emergency Management Agency (FEMA) and the French Natural Catastrophe Program (NatCat). Both programs learned early in their experience that affordable insurance, supplemented by federal grants for disaster management, can provide a strong incentive for disaster prone communities to join national risk reduction programs and adopt these programs' mitigation standards.

In the case of FEMA, no federal grants or loans are allowed for capital improvements in the flood-prone areas of non-participating communities. In addition, the Flood Disaster Protection Act of 1973 requires that anyone who applies for a mortgage from federally connected lenders – which means most lenders in the US – or who seeks federal disaster assistance or federal loans, must buy flood insurance if the property is in a high risk, flood hazard area. By making flood insurance and consequently mortgage financing unavailable to homeowners in communities not participating in risk reduction programs, the law created strong local pressures as well as powerful incentives for local politicians to join and actively implement the FEMA risk reduction programs.

The proposed reforms in risk financing should also translate into improved awareness of catastrophe risk by homeowners and enterprises, raising the level of insurance coverage in the country. Policy actions at the state and central level could include:

a. In the case of ex post sources of risk financing, having the GoI reward states pursing active catastrophe risk management with additional fiscal resources for rehabilitation of destroyed state-owned assets. It would be desirable to make the quantity of such additional financial assistance known in advance. For instance, the Government may consider offering a multiple of aid typically expected from the NCCF to the states that are advanced in risk-management. The financial resources for these extra-budgetary allocations could come from donors and IFIs, including the World Bank, or through reallocation of the GoI's planned financing for natural calamities. Ideally, over time, more government funding for natural calamity related work would be allocated through this channel.

[69] W. McCarten (2003).

b. Introduction by the states of a special tax on property or a surcharge on publicly provided services, the proceeds of which would be earmarked for rehabilitation of destroyed or damaged public infrastructure and would accumulate in the local CRFs.

c. Making infrastructure investments financed by IFIs contingent upon states submitting comprehensive risk management plans for the proposed investment. This would require government policy action that would not only safeguard the contemplated public investments but also promote broader active risk management approaches, including loss reduction and capability enhancement measures by the states.

Modify the existing institutional arrangements for disaster management at the center. While the existing institutional framework for catastrophe risk management is well developed and comprehensive, the following changes in the system would further facilitate active mitigation, build the capacity to effectively employ funds at the state level, and augment the existing ex post risk financing approach: [70]

a. The creation of a designated ***Risk Management Technical Assistance Unit*** **(RMTAU)** could be considered. The RMTAU would have two primary functions: (i) to serve as a technical resource for the RFF (see below), and (ii) provide Technical Assistance and Capacity Building support to the states preparing and implementing risk management initiatives. The RMTAU would operate as an independent unit hosted by the Central Relief Commission. It would be staffed with insurance and risk management professionals and would have an arms-length relationship with the RFF.

b. To promote better mitigation practices, the NCCF may also consider instituting a specially designated grant facility for mitigation initiatives of those states committed to reducing their funding gap. The RMTAU could house such a facility, funded by international donors or the GoI.

c. Adoption of ***Risk Management Plans*** **(RMPs)** by the states, with technical assistance from the RMTAU, would be formalized through an official document guiding all disbursements of disaster relief from the RFF. The RMPs for individual states are likely to include: (i) assessment of risk exposures and identification of the funding gap; (ii) targeted risk reduction measures to reduce the vulnerability of life-line infrastructure assets, including enforcement of building codes, improved land use practices, and structural re-enforcement of exposed assets; (iii) identification of risk exposures, such as privately-owned housing, which can be covered by private insurance; and (iv) acquisition of catastrophe insurance for peak risks for key public infrastructure, particularly when funded by the development lenders.

The facilitation of any risk financing initiative would require the creation of a new *Risk Financing Facility* (RFF) **to provide additional financial assistance to those states that are adopting and implementing a risk management approach.** The RFF would provide additional resources, sourced from donors, IFIs and the GoI for rehabilitation and repair of infrastructure. Disbursements from this facility would be made contingent upon (i) the occurrence of catastrophe events and (ii) achievement of risk management performance targets that would be agreed upon between the state and the facility, and certified by RMTAU.

[70] This ideally would be part of a larger risk management strategy.

Preliminary analysis suggests that the National Calamity Contingency Fund (NCCF) could be used as a hosting and managing organization for the RFF. However, to host the RFF, the NCCF would require sufficient loss assessment and claims settlement capabilities to ensure an expedient, fair and transparent compensation process.

Explore the use of contingent credit facilities for the purposes of catastrophe risk financing, and in support of risk management incentives at the state level. To finance reconstruction of public infrastructure and housing, the GoI has been utilizing World Bank and ADB emergency and reconstruction loans made in the aftermath of natural disasters. Some of the funding for reconstruction has also come from reallocations in the portfolios of developmental lenders. Despite the fact that most of these lending operations contained mitigation components, they have major inherent limitations. First, as evidenced by large funding gaps that exist at the state level, the GoI's reliance on ad hoc post disaster reconstruction loans from the development banks has done little to improve systemic risk management in the disaster prone states. Second, despite the considerably shortened time frames required for the preparation of emergency reconstruction loans when compared to the World Bank's other lending operations, emergency loans can be relatively slow to disburse (compared to immediately disbursing ex ante mechanisms) due to the World Bank's project procurement rules (although simplified) and other safe-guard policies.[71] As a result, these lending instruments are not appropriate for meeting the Government's immediate and often significant liquidity needs in the aftermath of natural disasters which, if unsatisfied, can have far reaching negative social and economic implications.

For instance, a contingent credit facility similar to that supporting the Turkish Catastrophe Insurance Pool (Box 2) could be extended to the NCCF in support of the RFF. Such a facility would then become available to meet claims of the states in the aftermath of natural disasters, provided an acceptable state risk management program is in place. Compliance with the terms set out in the risk management plan would be viewed as a major disbursement criteria. A matching contribution from the central government budget would be expected under such an arrangement. Such a contingent credit line would enable the RFF to operate as an effective fully pre-funded provider of liquidity to the disaster stricken states. If disbursed, the facility backing the RFF could be then replenished without any major costs. The above suggested funding approach for natural disasters would enable the Bank to switch to a proactive mode of lending for natural disasters by replacing multiple ex post future emergency lending operations with a single line of credit, and provide the GoI with immediate liquidity to meet reconstruction needs in the aftermath of natural disasters.

While unconstrained funds can be more expeditiously reallocated to changing project needs following a major catastrophic event compared to earmarked funds, the advantages of fungibility should be balanced by the increased importance of budgetary discipline. In the immediate post-loss environment, information is often scarce and the capability of the government to respond is stretched. Demands for shelter, food, water and health services for affected populations are immediate, as are those for the restoration of power and other critical services necessary for the resumption of economic activities. Conflicting demands as well as alternative visions for the future make it difficult to pursue value maximizing budgeting in the disordered and emotionally

[71] Note, this is based upon global experience and may or may not be directly relevant to India. In some countries it has been observed that though the World Bank's funding may be forthcoming post disaster, there is a significant delay in spending by the client.

charged post-disaster conditions.[72] However, the problem of post-loss liquidity inherent to the proposed model of funding natural disasters is not insurmountable. The key is to have a clear and well-prepared risk financing plan that can be used as the main framework for a post-emergency disaster funding budget. Such a plan can be worked out in advance in consultations with disaster prone communities, local and state governments, international donors and development lenders.

[72] Clarke and Doherty, "Development Enhancing Risk Management," Working paper, August 2003.

Box 2: Turkish Contingent Credit Facility

Background: Much of Turkey is exposed to severe seismic risk with the annual expected property loss estimated at around $1 billion. The death toll from the Marmara earthquake in 1999 is estimated at over 15,829 and physical damages are estimated to exceed $10 billion or around 3% of GNP. In addition, the Turkish economy is highly concentrated geographically, with the Istanbul metropolitan area accounting for over 50 percent of the national GDP.

The Government Earthquake Insurance Program: In the aftermath of the Marmara earthquake, the Turkish Government proposed an Earthquake Insurance Program that aimed at developing catastrophic risk transfer and risk financing mechanisms and institutions that can limit the government's financial exposure to future natural disasters. Under the Program, compulsory earthquake cover was introduced for all property-tax paying dwellings. The cover provided by the Turkish Catastrophe Insurance Pool (TCIP), offered coverage of up to $25,000 for each dwelling (pre devaluation). The program draws on the experiences of successful government efforts such as those of France, California, Florida, Spain and New Zealand in raising the financial preparedness for major catastrophic events via state sponsored catastrophe insurance pools, as well as the recognition by the Turkish government that catastrophe risks can only be funded through a certain degree of compulsion. The government has aimed at creating a pool in which sufficient earthquake reserves could to be accumulated on an affordable basis, while still reflecting risk levels.

The key objectives for the Program are defined by the General Directorate of Insurance (GDI) as follows:
- Ensuring that all property tax paying domestic dwellings have earthquake insurance coverage.
- Reducing government fiscal exposure to recurrent earthquakes.
- Transferring catastrophic risk to the international capital markets (including reinsurance).
- Encouraging risk mitigation and safer construction practices through the insurance mechanism.

The World Bank and Turkey: Over the years, the Bank has made several emergency and rehabilitation loans to Turkey. Despite the on-going and quite effective Bank emergency projects in the aftermath of natural disasters in Turkey, this type of lending has limitations. First, country exposure limits prevent the Bank from providing all needed liquidity in cases of larger catastrophic events. Second, emergency loans, given their large size, tend to crowd out other important development lending programs which have to be either postponed or substantially reduced. Third, as a development lender, the Bank is not suited to provide instant liquidity in the aftermath of disasters. Even in the case of record-breaking project preparation time for the TEFER (Turkey Emergency Flood and Earthquake Recovery Project) Loan, it took over 1.5 years to make the money available to the Government. Under TCIP, the World Bank has helped the government with two major activities: technical assistance to the GDI in establishing the TCIP and ensuring its operational efficiency and financial soundness for the first five years of its existence; and providing the initial capitalization of the TCIP through a contingent loan facility.

Initial Capital Support of the TCIP through an Uncommitted Contingent Loan Facility (US$100 million). This sub-component enabled the launch of the TCIP by providing $100 million of Bank financing in the form of an uncommitted contingent loan facility for the initial capital support of this institution. The disbursement of the proposed Bank facility was contingent upon: (i) progress made by the Government in enacting the above described package of regulatory reforms; (ii) satisfactory progress achieved in the technical work on the launch of the TCIP funded under the TEFER (Turkey Emergency Flood and Earthquake Recovery Project, 1998); (iii) the purchase of reinsurance from major international re-insurance providers; and (iv) presented evidence of insurance claims. To date the line of credit has remained undisbursed, and continues to support TCIP's total risk financing program, jointly with reinsurance, in the amount of approximately US$1 billion.

Introduce incentives and perhaps mandated requirements to increase the utilization of catastrophe insurance mechanisms by the private sector, including better off households.[73] These incentives/requirements could be part of the requirements mentioned above for additional funding from the center and are likely to vary between states according to local realities. Approaches that could be considered include:

- Requiring that replacement cost catastrophe insurance is purchased when mortgage financing is granted (see Appendix V). This in some cases could be effected through a relatively small addition to the interest rate and could even be accompanied by a slight offset reduction in the underlying interest rate reflecting the reduction in credit risk.
- Making it clear, if necessary through regulation, that households in the upper or middle income brackets are not eligible for government reconstruction funding (although they would continue to be eligible for relief).
- Tying catastrophe insurance into the land tax or land registration systems.
- Sales of catastrophe risk insurance policies to households and small businesses could be counted as partially contributing to the quotas specified by IRDA for the rural and social sectors, even if the risk concerned is in an urban area and the policyholder does not fall into the social category. Alternatively, specific requirements for catastrophe insurance penetration could be introduced.

Increase catastrophe reinsurance capacity in India by pooling all domestic catastrophe business written by insurers. This would produce a more balanced portfolio and conceptually should increase local retention capacity. A precedent already exists in India with terrorism insurance and such arrangements exist in a number of other developing markets (most recently Indonesia). However a precondition for this to work would be the upgrading and auditing of underwriting standards within the established insurance sector and the accurate and complete collection of accumulation data (see recommendations). A more formal catastrophe reserving system, based broadly on systems developed in countries such as Mexico and Canada, could also be instituted to increase capacity, and potentially be supported by short term tax incentives (in the long run taxes in this context are only a timing issue). Such facilities also lend themselves to contingent debt back up. Appendix I provides a complete description of international practice in this arena.

A final innovation that could be tested is to allow a very limited and select number of microfinance institutions (MFIs) to distribute catastrophe insurance products, with lower minimum capital requirements than those currently imposed on the formal sector insurance intermediaries. This would be subject to very strict criteria regarding management skills, minimum size of established membership, target markets and reinsurance arrangements. While micro catastrophe insurance is unlikely to be an attractive single purchase for most clients of MFIs, the technology exists for it be added to credit and other products, possibly at the village and self help level.

Recommendations

While the options outlined above will require consideration within the larger Indian fiscal and sectoral policy framework, the scope for further reform in the insurance sector to add capacity

[73] There is some question about the constitutional validity of any law that would require all households to purchase catastrophe insurance and some thought would be required as to how this constraint could be accommodated.

and increase the penetration of disaster insurance is relatively clear. For this reason we have characterized the relevant policy steps as recommendations.

The insurance sector should be further liberalized by removing current restrictions on, and cross subsidies from, the household and small business insurance markets. In particular, fire premium rates for households and small businesses should be completely liberalized over a relatively short time. While a standard policy wording should be maintained for market conduct purposes, insurance companies could be allowed to vary this wording through a derogation statement approved by the regulator and attached to the policy document. This will encourage contract innovation and introduce effective price competition. Prior to the complete liberalization of rates a modern claims experience database should be established, categorized according to relevant rating factors, and technically advanced rating methodologies should be introduced to the industry. The authorities could then keep overall control in the medium term by introducing a file and write system.[74] Advisory catastrophe primary premium rates, based on technically sound assessment of the relevant hazards, long term reinsurance pricing, and vulnerabilities and uncertainties could also be made available to the insurance industry as a socially desirable public good.

Claims handling procedures in the event of natural disasters should be streamlined and formalized. In this regard the facilitating actions of the national insurers following the Bhuj earthquake should be encouraged rather than questioned, subject to adjusters and claims officers demonstrating adequate levels of professionalism and preparation.

More explicit rules should be introduced as to insurers' minimum premium retentions and maximum risk retentions. In particular, IRDA should begin to require all insurers to gather detailed aggregate catastrophe accumulation data and to monitor insurers' relevant exposures on at least an annual basis.

[74] Under a file and write system the insurer submits rates to the supervisor but can begin to use them if there is no response after a defined period, typically 60 days.

Annex I: India's Disaster History

Table 17: List of Largest Cyclones in India (1891-2000)

Sl. No.	State	Date	Location	Damage	Wind speed at land fall (kmph)
1	Andhra Pradesh	1925, May12-20	Crossed Machilipatnam	Deaths: 80 people.	
2	Andhra Pradesh	1927, October 29-November 3	Crossed Andhra Pradesh coast near Krisnapatnam, about 20 km southeast of Nellore	In few coastal villages the sea overflowed, played great havoc from Kavour to Gudur. Deaths: 629 people.	
3	Andhra Pradesh	1938, November 21-25	Crossed Machilipatanam	Railway bridge washed away. Extensive damage to waterworks due to saline water intrusion.	
4	Andhra Pradesh	1943, October 31	Crossed Kalingapatnam	At Kalingapatnam a tidal wave swept into the town and combined with floods in river Vamsadhara and caused great damage.	
5	Andhra Pradesh	1945, October 15-21	Crossed Machilipatnam	The extent of inundation: coastal districts of Godavari and Krishna districts (15N-17N).	
6	Andhra Pradesh	1946, November 6-11	Southeast of Nellore	Deaths: 750 people and 30,000 cattle head. Damage to property and roads also reported.	
7	Andhra Pradesh	1949, October 21-30	Crossed near 10 km southeast of Narasapuram near Masulipatnam	Deaths: 800 people and 30,000 cattle head. Houses destroyed: 0.25 million. Crops destroyed: over 1 million acres. Heavy damages to huts/buildings/plantations.	
8	Andhra Pradesh	1955, October 6-14	Crossed Kalingapatnam	Deaths: 500 people and 100000 cattle head. Heavy loss of property. Communication completely dislocated.	66
9	Andhra Pradesh	1969, November 4-9	Crossed between Masulipatnam and Kakinada	Deaths: 900 people. Kolletikota Island hamlet of Krishna district was completely submerged under 8-10 ft of water. Property damage of Rs. 200 crores.	174
10	Andhra Pradesh	1977, November 14-20	Crossed north of Chirala 60 km east of Ongole	Deaths: 10,000 people, 5,74,204 cattle head/ other animals, Population affected: 71 lakhs. Cropped area affected at acres: 36 lakhs. Houses damaged/destroyed: 10,10,336. Damage to public utilities: Rs. 11 crores.	259
11	Andhra Pradesh	1979, May 5-13	Crossed near Ongole between Nellore and Kavali	Population affected: 40 lakhs. Deaths: 700 people, 300,000 cattle heads. Loss of property: Rs.170 crores. Crops destroyed: over 0.7 lakh acres.	202
12	Andhra Pradesh	1984, November 9-14	Crossed south Andhra Pradesh coast just north of Sri Harikota	Deaths: 541 people. 84,000 people homeless. Extensive damage to several installations at Rocket Launching and Tracking Station at Sri Harikota. 91 meters Meteorological Tower broken.	112
13	Andhra Pradesh	1987, October 14-19	Crossed north of Ongole	17 deaths, substantial damage.	67
14	Andhra Pradesh	1987, October 31-November 3	Crossed Nellore	Deaths: 50 people and 25,800 cattle head. 8400 houses damaged. Roads and communication disrupted.	72

Source: Various sources.

Table 17: List of Largest Cyclones in India (1891-2000) (cont'd)

Sl. No.	State	Date	Location	Damage	Wind speed at land fall (kmph)
15	Andhra Pradesh	1989, November 3-9	Crossed near Kavali	Destruction in Nellore and Kavali. Deaths 69 people. 55.5 lakhs families homeless.	213
16	Andhra Pradesh	1990, 4-10 May	Crossed 40 km southwest of Machilipatnam	Deaths: 967 people, 3.6 million livestock. 14,000 houses damaged. Loss of property Rs.2289.6 crores.	164
17	Andhra Pradesh	1996, June 12-16	Crossed near Vishakhapatnam	Deaths: 68 people. Damages were mainly due to breach of tanks and reservoirs, not due to wind and surges. Property/infrastructure loss: Estimated to be Rs.82 crores.	65
18	Andhra Pradesh	1996, November 4-7	Crossed Andhra Pradesh coast nearly 50 kms south of Kakinada in the east Godavari districts	Heavy damages caused to infrastructure, roads, buildings, etc. 7 million families were affected. Deaths: About 1,057 people. 925 people (mostly fishermen) missing. 1.74 lakhs hectares of crops damaged.	119
19	Gujarat	1964, June 9-13	Crossed near Naliya	Deaths: 27 people. Extensive damage.	161
20	Gujarat	1975, October 19-24	Crossed Saurashtra coast near Porbandar	Deaths: 85 people. Several thousand houses damaged.	185
21	Gujarat	1976, May 29-June 5	Crossed Saurashtra coast near Gopinath point (between Mahuva and Bhavnagar)	Deaths: 87 people, 4500 cattle head. Extensive damage.	157
22	Gujarat	1982, November 4-9	Crossed near Veraval	Deaths: 542 people, 1,50,332 cattle head. Extensive damage houses and buildings.	149
23	Gujarat	1996, June 17-20	Crossed south Gujarat coast close to Diu	Deaths: 47 people. 30,000 houses destroyed.	109
24	Gujarat	1998, June 4-10	Crossed Gujarat coast near Porbandar	Deaths: 1,250 people, 11,700 animals. Total damage caused by the cyclone in Gujarat alone was estimated to be Rs.1334 crores. The cyclone caused considerable damage in Rajasthan as well. The Kandla Port Area was the most severely affected area within the Kutchh District. About 2.57 lakhs houses were damaged.	165
25	Orissa	1909, October 24-27	Near Gopalpur	Extensive damage.	
26	Orissa	1959, September 27-October 2	Crossed north of Balasore in the night of 30th September	Low lying regions round Calcutta heavily flooded for two days.	139
27	Orissa	1971, October 26-30	Crossed near Paradip	Deaths: about 10,000 people.	185
28	Orissa	1972, September 7-14	Crossed near Barua	Storm surge of height varying from 1-3 m above astronomical tide affected the coast from Chandbali to Barua.	195
29	Orissa	1972, September 20-25	Crossed near Gopalpur	Inundation in Puri district.	185
30	Orissa	1973, October 6-12	Crossed Chandbali	Deaths: 100 people.	83
31	Orissa	1982, May 31-June 5	Crossed near Paradip	Deaths: 245 people. Very heavy damage was caused all along from Paradip to Balasore	134
32	Orissa	1995, November 7-10	Crossed near Gopalpur	Deaths: 96 people. 28,4253 hectares of crops damaged.	104
33	Orissa	1999, October 15-19	Crossed near Berhampur	Deaths: 205 people. 331000 houses damaged. 158,000 cropped area damaged. 5,181 villages were affected.	182
34	Orissa	1999, October 25-31	Crossed Orissa coast close to Paradip between Ersama and Balikuda (southwest of Paradip)	Deaths: 9,893 people, 444,531 livestock. The super cyclone affected 15 million people and more than 2 million households in the state.	259

Source: Various sources.

Table 18: Large Earthquakes in India

Year	Area	Date	Latitude degrees North	Longitude degrees East	Magnitude M	Max MMI
1819	Gujarat (Kutch)	16-Jan	-	-	8.0	XI
1833	Bihar	26-Aug	27.5	86.5	7.7	XI
1897	Assam (Shillong)	12-Jun	25.9	91	8.7	XII
1900	Kerala (Palghat)	8-Feb	10.7	76.7	6.0	-
1905	Himanchal Pradesh (Kangra)	4-Apr	32.5	76.5	8.0	XI
1930	Assam (Dhubri)	3-Jul	25.8	90.2	7.1	IX
1934	Bihar – Nepal	15-Jan	26.6	86.8	8.3	XI
1941	Andamans	26-Jun	12.4	92.5	8.0	X
1943	Assam (NE)	23-Oct	26.8	94	7.2	X
1950	Assam (NE)	15-Aug	28.7	96.6	8.6	XII
1956	Gujarat (Anjar)	21-Jul	23.3	70	7.0	VIII
1956	Uttar Pradesh (Bullandshahar)	10-Oct	28.1	77.7	6.7	VIII
1958	Uttar Pradesh (Kapkote)	28-Dec	30	80	6.3	VIII
1960	Delhi	27-Aug	28.3	77.4	6.0	VII
1963	Kashmir (Badgam)	2-Sep	33.9	74.7	5.5	VII
1966	Western Nepal	27-Jun	29.5	81	6.3	VIII
1966	Uttar Pradesh (Moradabad)	15-Aug	28	79	5.3	VII
1967	Nicobar	2-Jul	9	93.4	6.2	-
1967	Maharashtra (Koyna)	11-Dec	17.4	73.7	6.5	VIII
1969	Andhra Pradesh (Bhadrachalam)	13-Apr	17.6	80.6	6.0	VII
1970	Gujarat (Broach)	23-Mar	21.7	72.9	5.7	VII
1975	Himanchal Pradesh	19-Jan	32.5	78.4	6.5	VIII
1988	Bihar – Nepal	21-Aug	26.76	86.62	6.6	VIII
1991	Uttar Pradesh (Uttarkashi)	20-Oct	30.75	78.86	6.6	VIII
1993	Maharashtra (Killari)	30-Sep	18.07	76.62	6.3	VIII
1997	Jabalpur	22-May	23.1	80.1	6.0	VII+
1999	Uttar Pradesh (Chamoli)	29-Mar	30.5	79.3	6.8	VIII
2001	Gujarat (Bhuj)	26-Jan	23.4	70.32	7.9	X-XI

Source: Various sources.

Table 19: Summary of Major Flood Losses in India (1953-2001)

State / Country	Item	Area affected (M.Ha)	Damage to Houses (million $)	Damage to Public utilities (million $)	Total Damage (million $)
Andhra Pradesh	Average	0.31	4.22	21.09	44.18
	Maximum	3.48	69.85	344.91	588.89
Gujarat	Average	0.33	1.54	4.24	8.18
	Maximum	2.05	23.59	28.03	62.23
Maharashtra	Average	0.04	0.53	1.33	2.94
	Maximum	0.33	10.97	23.77	47.55
Orissa	Average	0.45	0.50	8.56	12.38
	Maximum	1.40	4.30	68.94	72.29
India	Average	7.57	37.45	112.69	280.33
	Maximum	17.50	272.04	659.65	1215.96

Source: CWC.

Table 20: Validation of MMIs with 2001 Bhuj earthquake

Block Name	Observed MMI	Modeled MMI	Ratio Modeled/ Observed
Bhachau	10.0	9.8	0.98
Anjar	9.0	8.5	0.94
Rapar	10.0	7.4	0.74
Maliya	7.0	7.3	1.05
Bhuj	8.0	7.2	0.91
Mandvi	7.0	6.7	0.96
Santalpur	9.0	6.7	0.75
Halvad	7.0	6.4	0.92
Radhanpur	8.0	6.4	0.80
Nakhatrana	7.0	6.4	0.91
Morvi	7.0	6.4	0.91
Viramgam	6.0	6.1	1.01
Jamnagar	7.0	6.0	0.86
Rajkot	6.0	5.7	0.95
Gandhinagar	6.0	5.6	0.94
Ahmadabad City	6.0	5.5	0.91

Source: RMS Delhi.

Table 21: Validation of MMIs with 1993 Latur Earthquake

Block Name	Observed MMI	Modeled MMI	Ratio Modeled/Observed
Ausa	7.0	6.9	0.99
Umarga	7.0	6.1	0.87
Nilanga	6 to 7	5.7	0.88
Udgir	6.0	5.5	0.92
Osmanabad	6.0	5.4	0.90
Tuljapur	6.0	5.3	0.88
Kalamb	6.0	5.0	0.83
Ambejogai	6.0	5.0	0.83
Akkalkot	6.0	5.0	0.83
Barshi	6.0	5.0	0.83
Ahmadpur	6.0	5.0	0.83
Latur	6.0	5.0	0.83

Source: RMS Delhi.

Table 22: Validation of wind speeds with 1977 Andhra Pradesh cyclone

Station	Observed peak gust (mph)	Modeled peak gust (mph)	Ratio Modeled/Observed
Ongole	93.64	90.60	0.97
Masulipatnam	110.18	108.72	0.99
Gannavaram	120.78	116.54	0.96
Madras	29.58	31.09	1.05

Source: RMS Delhi.

Table 23: Validation of wind speeds with 1999 Orissa cyclone

Station	Observed peak gust (mph)	Modeled peak gust (mph)	Ratio Modeled/Observed
Paradip	129.37	148.09	1.14
Bhubaneshwar	155.43	122.14	0.79
Puri	179.98	67.78	0.38

Source: RMS Delhi.

Annex II: Loss Summary Tables

The following tables are referred to in Chapter III.

Table 24: Average annual loss summary (US$ Million)

State	Parameter	Combined assets			
		All perils	Cyclone	Earthquake	Flood
AP	AAL	82.9	61.2		21.7
	SD		148.6		40.0
GJ	AAL	64.9	26.0	16.9	22.0
	SD		99.0	142.2	39.9
MR	AAL	2.8		2.8	
	SD			42.9	
OR	AAL	43.2	35.2		8.0
	SD		84.3		22.9

Source: RMS Delhi.

Table 25: Average Annual Loss Summary (US$ Million)

State	Parameter	Housing				Public infrastructure			
		All perils	Cyclone	Earthquake	Flood	All perils	Cyclone	Earthquake	Flood
AP	AAL	60.3	44.1		16.2	22.7	17.1		5.5
	SD		116.3		29.7		37.4		10.3
GJ	AAL	52.9	21.9	15.0	16.1	12.0	4.1	2.0	5.9
	SD		88.9	126.4	27.9		11.6	16.2	12.5
MR	AAL	2.5		2.5		0.3		0.3	
	SD			40.9				2.2	
OR	AAL	26.6	22.6		4.0	16.6	12.6		4.0
	SD		53.2		11.2		32.8		11.7

Source: RMS Delhi

Table 26: Probable Maximum Loss Summary (US$ Million)

State	Peril	Combined assets	Housing	Public infrastructure
AP	All Perils	921	739	205
		2.1%	2.6%	1.4%
	Cyclone	911	733	203
		2.1%	2.6%	1.4%
	Flood	191	142	49
		0.4%	0.5%	0.3%
GJ	All Perils	1,009	888	128
		2.1%	3.1%	0.7%
	Cyclone	517	461	61
		1.1%	1.6%	0.3%
	Earthquake	733	669	76
		1.5%	2.3%	0.4%
	Flood	223	155	71
		0.5%	0.5%	0.4%
MR	Earthquake	59	49	9
		0.1%	0.1%	0.0%
OR	All Perils	479	288	177
		3.2%	4.1%	2.2%
	Cyclone	477	290	177
		3.2%	4.1%	2.2%
	Flood	130	63	67
		0.9%	0.9%	0.8%

Source: RMS Delhi

Annex III: Insurance Consumption By State

Table 27: Insurance Penetration %

	Net Domestic Product 1998-99(Rs billion)	Per Capita Income 1998-99 (Rs)	Non-Life Premium (Rs billion)	Ratio of Premium to the State Net Domestic Product (%)
Western Region				
Goa	35.81	24,309	0.55	1.5
Gujarat	888.22	18,792	8.22	1.0
Madhya Pradesh	789.46	10,147	3.12	0.4
Maharashtra	2041.20	22,763	22.26	1.0
				Northern Region
Delhi	406.86	29,623	8.33	2.0
Haryana	383.99	19,773	1.55	0.4
Himachal Pradesh	82.10	12,692	0.36	0.4
Jammu and Kashmir	98.62	10,272	0.53	0.5
Punjab	487.68	20,834	3.06	0.6
Rajasthan	576.99	11,045	2.55	0.4
Uttar Pradesh	1527.26	9,261	5.87	0.4
Southern Region				
Andhra Pradesh	1028.76	13,853	5.13	0.5
Karnataka	812.76	15,889	4.64	0.6
Kerala	565.63	17,756	3.20	0.6
Tamil Nadu	1052.56	17,725	8.15	0.8
				Eastern Region
Assam	223.87	8,700	0.86	0.4
Bihar	627.59	6,328	1.51	0.2
Manipur	25.50	10,599	0.03	0.1
Meghalaya	28.06	11,678	0.13	0.5
Orissa	308.57	8,719	0.97	0.3
Sikkim	5.91	10,990	0.03	0.5
Tripura	36.47	9,768	0.06	0.2
West Bengal	1155.43	14,705	4.90	0.4

Source: CIRE (Indian Institute of Management), Report Commissioned by World Bank, 2002.

Annex IV: Central Relief Funds Flows To States

Table 28: Annual Margin Money/CRF Allocated to the States by Successive Finance Commissions (Rs Million)

SL No.	State	Sixth 1974-79	Seventh 1979-84	Eighth 1984-89	Ninth[1] 1990-95	Tenth[1] 1995-2000[2]	Eleventh 2000-2005[2]
1	Andhra Pradesh	43	86	245	860	1,307	2,189
2	Arunachal Pradesh	-	-	-	20	74	138
3	Assam	13	34	73	30	527	1,122
4	Bihar	46	131	338	350	547	1,367
5	Goa	-	-	-	10	11	14
6	Gujarat	46	96	288	850	1,470	1,784
7	Haryana	12	15	45	170	264	899
8	Himachal Pradesh	0	1	2	18	26	481
9	Jammu & Kashmir	4	5	15	120	208	386
10	Karnataka	19	20	60	270	441	824
11	Kerala	3	16	50	310	583	743
12	Madhya Pradesh	34	18	48	70	538	996
13	Maharashtra	42	46	73	440	718	1,737
14	Manipur	0	1	3	10	26	37
15	Meghalaya	0	1	3	20	29	44
16	Mizoram	-	-	-	10	13	(33)
17	Nagaland	0	1	3	10	18	22
18	Orissa	36	87	263	470	516	1,210
19	Punjab	3	27	60	280	570	1,356
20	Rajasthan	102	77	168	1,240	1,885	2,288
21	Sikkim	-	0	3	30	50	76
22	Tamil Nadu	15	86	88	390	625	1,134
23	Tripura	1	2	8	30	47	58
24	Uttar Pradesh	22	108	325	900	1,317	1,974
25	West Bengal	66	136	238	400	540	1,117
	TOTAL	**507**	**1,006**	**2,408**	**8,040**	**12,609**	**22,015**

[1] Indicates the Calamity Relief Fund.
[2] Indicates the annual average of the five year devolution 1995-2000 and 2000-2005.

Source: Disaster Management Facility with Consultants, June 2002.

Table 29: Releases from National Fund for Calamity Relief (Rs Million)

States	1995-96	1996-97	1997-98	1998-99	1999-00	Total
Andhra Pradesh	-	1,630	420	265	754	3,069
Arunachal Pradesh	-	1	-	135	-	265
Assam	-	21	-	599	-	809
Bihar	-	280	100	115	382	876
Gujarat	-	-	869	554	546	1,968
Haryana	394	-	-	133	-	527
Himachal Pradesh	125	106	248	-	-	479
Jammu & Kashmir	182	-	-	-	734	916
Karnataka	-	-	220	500	171	891
Kerala	-	-	129	-	-	129
Madhya Pradesh	-	-	678	350	389	1,416
Meghalaya	-	100	-	-	-	100
Mizoram	47	-	-	-	60	107
Orissa	258	550	40	-	8,282	9,129
Punjab	162	-	-	-	-	162
Rajasthan	-	210	-	220	1,029	1,459
Sikkim	-	55	70	77	-	202
Tamil Nadu	-	250	-	-	-	250
Tripura	-	-	-	51	53	104
Uttar Pradesh	-	-	-	1,312	167	1,478
West Bengal	-	210	-	663	295	1,169
Manipur	-	-	-	-	49	49
Total	**1,167**	**3,731**	**2,774**	**4,971**	**12,910**	**25,553**

Source: Disaster Management Facility with Consultants, June 2002.

Annex V: Andhra Pradesh Post Disaster Experience

Table 30: Andhra Pradesh Post Disaster Experience: 1996 cyclone

1996 Cyclone

	Damage Crs	Damage USD-Millions	% (less hort&housing)	Capital Budget 1996-1997 Crs.(*)	Damage as a % Capital Budget	Relief Request Crs.	% Damage
Agriculture	397	111.7	38.6%	12	3277.1%	50	13%
Horticulture	4137	1,165.3				350	8%
Panchayath Raj	150	42.3	14.6%			130	87%
Irrigation & CAD	100	28.2	9.7%	611	16.4%	80	80%
Municipal Administration	120	33.8	11.7%			100	83%
Animal Husbandry	45	12.7	4.4%			30	67%
Fisheries	40	11.3	3.9%			40	100%
A.P Housing	964	271.4				1042	108%
Medical and Health		-					
Roads and Buildings	35	9.9	3.4%	196	17.9%	35	100%
A. P. TRANSCO-Electricity	102	28.9	10.0%			102	100%
Other	37		3.6%			33	
Immediate Relief& Public Health						150	
Total	**6126**	**1,715.3**				**2143**	**35%**
Total less Horticulture and housing	**1,026**	**278.59**	**100.0%**	**1276**	**80.4%**		

Relief grant- from Delhi		163
Distribution	ex-gratia	67
	private	50
	public	46

(*)-1996-97 Budget is assumed to be average of 1995/96 and 96/97 due to energy budget fluctuations in those two years

Public Sector Funding Gap Ratio 96%

crs.= crores
1 crs. = 10,000,000 rps — 281,690 USD/crs
1 rps = .02816 USD (35 rps= 1 USD)

Source: Government of AP

Table 31: Andhra Pradesh Post Disaster Experience : 2001 Flooding

2001 Flooding

	Damage Crs	Damage USD-Millions	% less hort and housing	Capital Budget 2001-2002 Crs.	Damage as a % Capital Budget	Relief Request Crs.	% Damage
Agriculture	68	14.5	13.6%	18	370.0%	20	29%
Horticulture	13	2.7				5	40%
Panchayath Raj	60	12.8	11.9%			25	42%
Irrigation & CAD	72	15.4	14.4%	1170	6.2%	50	69%
Municipal Administration	41	8.6	8.1%			15	37%
Animal Husbandry	3	0.6	0.6%				0%
Fisheries	20	4.3	4.0%			5	25%
A.P Housing	409	87.0				69	17%
Medical and Health	54	11.5	10.8%			15	28%
Roads and Buildings	160	34.1	31.8%	759	21.1%	50	31%
A. P. TRANSCO-Electricity	25	5.2	4.9%	22	110.8%	25	100%
Total	**925**	**196.7**				**278**	**30%**
Total- less Hort and Housing	**503**	**107.0**	100.0%	**3091**	**16.3%**		

Relief grant- from Delhi		30
Distribution	public	10
	private	20

Public Sector Funding Gap Ratio 98%

crs.= crores

1 crs. = 10,000,000 rps 212,766 USD/crs

1 rps = .0212 USD (47 rps= 1 USD)

Source: Government of AP

Annex VI: Bhuj Earthquake Capability/Funding Gap

Table 32: Sources and uses of funds (US$ million)

Planned Expenditure for 2000 and 2001		Sources of Funds		
Item	**Amount**	**Source**	**Tentative and agreed**	**Received by end 2002**
Housing	1,349	World Bank	996	105
Health	60	ADB	503	75
Education	179	CRF (both years)	75	38
Dam safety & irrigation	91	NCCF (both years)	314	207
Public buildings	95	Non-plan central assistance	171	54
Roads and bridges	27	Chief Minister's relief fund	24	
Urban infrastructure	86	PM's relief fund	64	
Rural infrastructure	131	Bilaterals	256	10
Power	98	Tax free bonds	428	96
Livelihood rehabilitation	20	CSS	161	
Community participation	10	State government	321	
Disaster management capacity	40	Possible advance on NCCF 2003	278	
Industry	128			
Agriculture	86			
Other	15			
Total	2,415	Total	3,591	765

Source: MOF GoI.

Annex VII: Brief Overview Of Indian Mortgage Market

In recent years the Ministry of Finance and the Reserve Bank of India have been taking steps to develop a consumer finance industry in India. At present the housing finance industry is estimated to be disbursing approximately US$5 billion annually and is growing at 40% per annum, with expectations that this will continue for at least a decade. This growth estimate is supported by a leveling out of real estate prices and declining interest rates that have increased affordability, and by the growing presence of housing finance intermediaries. In addition, the central government has provided a direct tax rebate on housing loans to individual households.

A number of institutional features continue to inhibit development of housing finance, not the least of which are penal stamp duty rates in some states and the varying quality of land record keeping. These inefficiencies are now being gradually addressed.

The longest established direct lender is HDFC, with approximately 46% of the market. However, its influence has declined as other lenders have entered the market, including LIC, the nationalized banks, ICICI and a large number of smaller housing finance companies (HFCs), though many of the latter are expected to revert to purely agency roles. Refinancing is provided through a range of government sponsored organizations, with the largest, the national Housing bank (NHB) also acting as regulator. Commercial banks are now required to earmark 3% of their incremental deposits, or approximately US$1 billion annually for the housing sector.

In 2001 HDFC financed 1.9 million houses. A crude scaling up points to a 2-3% annual increment to the housing stock through mortgage financing. If mortgages granted in the last four years are added, this points to an initial potential catastrophe insurance market of at least 5% of the insurable housing stock.

Average loans vary between Rs 25,000 and Rs 90,000 depending on the institution and market segment involved and approximately 75% of loans are made to individual borrowers, with 50% being in urban areas. While demand remains strongest in the area around Mumbai, it is growing rapidly in other parts of India, the tribal areas excepted.

Annex VIII: US Consumers Union Perspective On Natural Disaster Insurance

Principles

Congress should not enact any legislation that provides relief to the insurance industry unless the legislation meets the following principles to ensure that it also benefits consumers and taxpayers.

Adequate Insurance Protection at Affordable Rates

- Any proposal must ensure that adequate insurance be available at affordable rates to all consumers, especially in high-risk areas.
- Low and moderate income homeowners should be protected from loss of insurance coverage.
- Deductibles, co-insurance and surcharges may all be ways to ensure that insurance is available but should not be used to render coverage levels meaningless.

Strong Mitigation Measures to Reduce the Costs of Disasters

- Any proposal must have as its focus mitigation and must provide for effective measures to reduce losses.
- All stakeholders must be included in mitigation efforts – central, state and local governments, businesses and consumers, and, most importantly, the insurance industry.
- The proposal should promote building and relocation efforts away from high-risk areas.
- The proposal must include measures to assist homeowners, especially low-income, in implementing damage-reduction measures.

Retention of Risk in the Private Market

- Any program must have as its goal retaining as much of the risk in the private market as possible, taking into consideration the capacity of the market and the type of risk involved.
- The property/casualty insurance industry has over $300 billion in surplus, the excess of assets over liability. Hurricane Andrew, the most costly disaster, caused $15.5 billion in insured losses. Clearly, the industry has a great deal of capacity that should be drawn upon before calling on the public to help.

Minimization of the Effects of Cross-Subsidization to Help Ensure that those in High-Risk Areas are the Primary Payers

- Cross-subsidization of risks should be limited to help ensure that those living in high risk areas pay their fair share for their protection.
- Pricing according to risk promotes building away from high risk areas, a key goal that should be a part of any program.
- In high risk areas, the various catastrophe risks could be pooled together, e.g., earthquake and hurricane, to help minimize rate disparities among different areas and to capitalize on the pooling of risks as much as possible.

Appropriate State and Federal Oversight

- Federal oversight of the insurance industry is essential if the federal government provides financial backup to the industry or states.
- While the federal government must oversee the industry if it provides financial support, states must retain the ability to provide the appropriate protections for their residents.

Demonstrated Benefits to the Federal Government's Disaster Relief Expenditures

- The Federal Emergency Management Agency provides an average of over $2 billion each year in disaster recovery and relief (1989-1997 average). The federal government as a whole provides even more relief. Any proposal should help reduce those costs to the federal government and taxpayers and should have a reasonable plan to accomplish this goal.

Questions to be Answered

- Before any proposal is enacted, Congress should have before it the necessary information to ascertain the extent of the problem and the effect of any solutions proposed.
  - For example, what is the capacity of the insurance and reinsurance markets today? What is the relationship between federal disaster aid and private insurance -- does disaster insurance decrease the costs of federal disaster relief? What is the effect of the various state actions on limiting losses of private insurers? How best can insurers be involved in the mitigation efforts to reduce costs? What are the costs of the various proposals to the federal treasury? to taxpayers? to consumers? to states? to the industry? What type of coverage is adequate to meet consumers' needs in disaster-prone areas?

Appendix I: International Experience With Catastrophe Funds

Overview – Even if the basic conditions for the mergence of an insurance market exist (see Appendix II), there are two rationales for government intervention in catastrophe insurance markets. The first emphasizes the high cost and limited supply of private capital.[75] According to the proponents of this view, a shortage of risk-bearing capital leads to an inadequate supply of insurance capacity, which keeps prices high relative to projected losses for low frequency high severity events, which is in turn socially sub-optimal. In 1994, for instance, catastrophe reinsurance premiums were more than seven times the expected loss although that multiple has dropped to between four and five more recently.[76] Proponents of this view also contend that government, with its vast capacity to tax and borrow, has an advantage over private insurers in bearing catastrophe risk because it does not need to hold explicit capital to pay off claims and avoid bankruptcy.[77] To free insurers from the costly burden of holding huge amounts of capital, proponents suggest that the government act as a residual provider of reinsurance for so-called mega-catastrophes. The government could set premiums below those charged by private insurers, thus lowering the cost of insurance while protecting taxpayers from losses. The second view emphasizes that the biggest barrier to an adequate supply of insurance, especially immediately after a catastrophe, is insurers' heightened uncertainty about the frequency and size of future losses. After Hurricane Andrew, the Northridge earthquake, and the World Trade Center attacks, insurers were not certain that they could assess the risks they were being asked to assume. Without such knowledge, they were unwilling to commit capital by underwriting the coverage. In time, insurers are usually able to recalibrate their estimates and reenter the market. Thus, proponents of this view contend that the government needs to intervene to supply insurance while insurers reassess risk after a disaster, but they argue for a temporary government role.[78]

Actual experience has been that mounting uninsured losses from natural disasters have pressed governments in disaster prone countries and regions to look for practical solutions for catastrophe risk management, spurring the formation of national and regional catastrophe insurance programs.

To date, 12 national catastrophe risk management programs have been established and are operating successfully in 10 different countries, with the sole purpose of providing affordable catastrophe insurance coverage for homeowners. While design and coverage features provided by these insurance programs vary, the underlying rationale for their introduction has been the same - to address the challenges faced by the private insurance markets in insuring the risk of natural disasters. Table A 1.1 lists the most well known of these programs, which include TCIP in Turkey, FONDEN in Mexico, the FHCF in Florida, the HHRF in Hawaii, CEA in California, EQC in New Zealand, NatCat in France, and Norway's Norsk Naturskadepool. The two most recent of these -TCIP and the Taiwan Pool (Box A 1.1), have been established in the last four

[75] For example, see D. M. Cutler and R. Zeckhauser (1999).

[76] Premiums for the highest layers of coverage (the lowest probability layers) were between 20 and 30 times expected losses in 1994, according to estimates. K. Froot (2001) and Figures 3 and 4. However, research emphasizes the imprecision of the estimates of actuarial losses for the least likely events. See J. Moore (1999), available at http://fic.wharton.upenn.edu/fic/.

[77] Statement of Lawrence H. Summers, Deputy Secretary, Department of the Treasury, before the House Banking and Financial Services Committee, April 23, 1998.

[78] Proposal on Federal Reinsurance for Disasters, Congressional Budget Office, September 2002.

years, while it appears that New Zealand is winding down its scheme, reflecting the maturity and depth of market solutions now available in that country.

Table A 1.1: Government Sponsored Catastrophe Insurance Programs

Name of the Fund	Country	Year Established & Risk Covered
Turkey Catastrophe Insurance Pool **(TCIP)**	Turkey	2000/ Earthquake
Catastrophe Naturelles **(CatNat)**	France	1982/ All Natural Disaster except for Windstorm, ice and snow
Japanese Earthquake Reinsurance Company **(JER)**	Japan	1966/ Earthquake, tsunami, and volcanic damage
Earthquake Commission **(EQC)**	New Zealand	1994/ Earthquake, tsunami, volcanic damage, landslide.
Norsk Naturskadepool	Norway	1980/ Floods, storms, earthquakes, avalanches, tidal waves
Consorcio de Compensación de Seguros	Spain	1954/ Earthquakes, tidal waves, floods, volcanic eruptions, and cyclonic storms.
Taiwan Residential Earthquake Insurance Pool **(TREIP)**	Taiwan	2002/ Earthquake
Florida Hurricane Catastrophe Fund **(FHCF)**	USA	1993/ Windstorm during a hurricane
Hawaii Hurricane Relief Fund **(HHRF)**	USA	1993/ Windstorm during a hurricane
California Earthquake Authority **(CEA)**	USA	1996/ Earthquake

Note: None of the above mentioned insurance programs insure public infrastructure assets or provide/finance emergency relief services.

Natural catastrophe risk is unique due to its highly systemic nature. Since 1989, there have been 15 natural disasters in the United States alone, resulting in US$ 43 billion of insured losses, and it is no longer unusual for the global insurance industry to sustain losses from a single catastrophic event in excess of US$ 1 billion. The management of these catastrophe risk exposures is highly capital intensive and it is hard if not impossible to diversify away these exposures at the level of primary insurers. In the aftermath of natural disasters, private insurance markets have tended to ration or, in some cases, discontinue offering their catastrophe insurance coverage for homeowners or small business unless some sort of a risk sharing arrangement with the government is put in place.[79]

[79] Apart from catastrophe insurance programs presented in Table 1 below, some countries have opted for public sector managed and financed disaster funds with the primary objective of providing ex post disaster assistance to a) low-income households, and b) to carry out immediate repairs (but not necessarily replacement) of damaged infrastructure assets in the wake of natural disasters. An overview of these disaster relief funds is beyond the scope of this paper.

Box A 1.1 – Public/ Private Catastrophe Funding

The Turkish Catastrophe Insurance Pool (TCIP)
TCIP became operational on September 27, 2000 and is based on a separate law. Key elements of the scheme are that it is compulsory for all registered dwellings, that the government reconstruction commitment for such dwellings ceases, that TCIP is the sole source provider for base level earth quake coverage and that TCIP is managed professionally by Turkey's national reinsurer, Milli Re. It is also planned that the initial decree law will be enhanced to strengthen the enforcement and hence coverage of the new system. The scheme rapidly became the second largest earthquake pool in the world with approximately 2 million policies. Technical specifications include the following:

1. This is a stand alone product, separate from fire and homeowners contracts.
2. Based on exchange rates at the time of introduction the scheme covered up to $20,000 per dwelling, but there is no contents cover.
3. There are 15 rating categories based on hazard zone and construction type, with premiums ranging from less than US$10 to in excess of US$50.
4. Cover in excess of the limit available through TCIP is available from private sector insurers.
5. Private sector insurers distribute TCIP policies through their agency forces and collect a master agency commission and administration fee.
6. To reduce administration costs and spurious claims a 2% deductible is applied.
7. Claims handling is handled directly by TCIP contracted loss adjusters.
8. Reserves are held in creditor proof escrow accounts, with at least 50% invested in foreign assets.
9. Reinsurance is purchased up to the 99th percentile of possible losses, or approximately US$1 billion.
10. The World Bank has provided lending for initial institutional development, and reinsurance purchases, and has also established a contingent debt facility which can be applied flexibly.

The Taiwan Residential Earthquake Insurance Scheme
Taiwan has also introduced an earthquake scheme following a major event, commencing April 1st, 2002 and effected through amendments to the basic insurance law. The approach adopted reflects the greater level of development of the insurance sector in Taiwan. Key elements are that earthquake insurance is automatically included in domestic fire and homeowners' policies, but that the purchase of the basic policy is voluntary. There are four layers to the scheme, with the local insurance sector and the Central Reinsurance Company taking the first NT$2 billion (US$65 million) of exposure, a government guarantee fund taking the next NT$20 to 30 billion, international reinsurers taking the next NT$10 billion and the government budget being exposed there after. Technical specifications include:

1. Coverage is incorporated into the basic fire/homeowners contract.
2. Coverage is for the dwelling itself, with some temporary accommodation cover but not for contents.
3. The per dwelling limit is NT$1.2 million (US$ 39,000), and a flat premium of NT$1,459 (US$47) applies.
4. Coverage above the basic limit may be obtained from private insurers.

Design Features of Catastrophe Insurance Programs - A survey of the 12 major national programs reveals some major similarities.[80] Most programs (1) tend to focus on providing coverage against a specific natural hazard; (ii) tend to have a regional focus; (iii) cover mainly for dwellings and contents; (iii) have premium rates which tend to reflect the characteristics of the risk, with an element of solidarity involved which effectively provides for cross-subsidies from better risks to worse; (iv) as a rule, these programs receive no direct government subsidies; (v) mitigation is not typically a major focus, although some programs encourage retrofitting and safer construction practices by offering premium discounts; and finally (vii) sales and servicing

[80] Guy Carpenter, World Catastrophe Reinsurance Market (2002).

are typically carried out through the established distribution networks of private primary insurance companies and their agents.

Table A 1.2 below provides a convenient overview of key design choices available to policy makers and insurance practitioners involved in the creation of national catastrophe insurance programs. A more detailed discussion of these design options follows.

Table A 1.2: Catastrophe Program Design Variables

Program Variables	Design Choices
Management	Public/ Private
Governance	Public/ Private/ Mixed
Funding	Public/ Private/ Mixed
Insurance Vehicle	Insurance Pool/ Reinsurance Pool/ Insurance Companies
Coverage	Buildings; Contents; Business Interruption
Lines of Business	Residential/ Commercial (SMEs)
Rates	Flat/ Risk-based/ Mitigation Incentives
Distribution	Insurance Companies/ Alternatives
Retentions by Insurance Companies	0 to risk based solvency margin
Geographical Coverage	National/ Regional/ Inter-country
Participation	Compulsory/ Voluntary
Reinsurance	Private/ Public mix

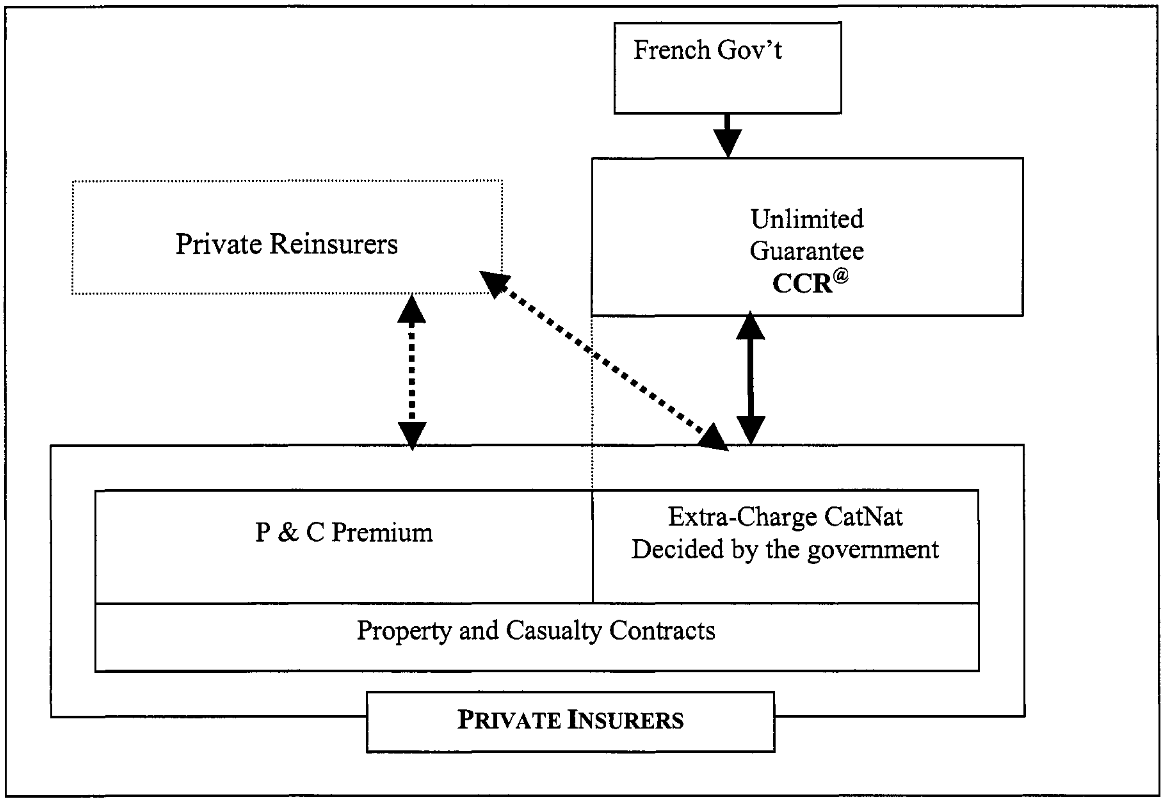
Management and Governance

Less than a third of catastrophe insurance programs mentioned in Table A 1.1 are managed by the government, with NatCat of France and CEA of California being the primary examples. Nevertheless, it should be noted that even in privately run programs, government influence and control remain strong through some form of government representation on their Boards, which ultimately makes catastrophe insurance programs accountable to the public. In most cases an independent professional fund/pool manager has been retained to carry out its day-to-day operations. Typically, the primary functions of the fund manager include but are not limited to (a) collection of premium, (b) claims management; (c) asset management and (d) placement of reinsurance. Investment functions are carried out in accordance with the guidelines established by the Governing Boards of Directors.

In some cases, such as the Florida Hurricane Insurance Pool, catastrophe programs have their own direct distribution channels in addition to those of participating private insurers. Most of these entities tend rely heavily on the distribution and servicing capabilities of primary insurers. For instance, in the case of the Turkish TCIP, the pool manager is the country's largest reinsurer, Milli Re, which markets earthquake coverage through the distribution channels of the Turkish insurers. In case of claims adjustment, the TCIP relies on independent loss adjusters mobilized by insurance companies responsible for handling respective claims. The pool managers are typically compensated for their services with a management fee which varies widely – from 0.8 percent of the net written premium in the case of FHCF to 2 percent in the case of JER. In some cases the management fee is contingent upon achieving certain performance benchmarks such as a certain level of insurance penetration for the pool's major business line.

Besides direct involvement in the operations of a pool or through representation on the Board, government has another important role to play, to be a reinsurer of last resort. In the case of NatCat (Figure A 1.1), for instance, the French government provides a sovereign guaranty to the state-owned reinsurer CCR for all claims in excess of its claims paying capacity. In New Zealand, for EQC, the government guarantees to its policyholders that it would assume the financial responsibility for meeting the EQC's residual claims that are over and above its claims paying capacity.

Figure A 1.1: French NatCat System



@ CCR – Caisse Centrale de Reassurance, the public reinsurer. The French government offers the CCR a non-limited guarantee, meaning that the government is the reinsurer of last resort.

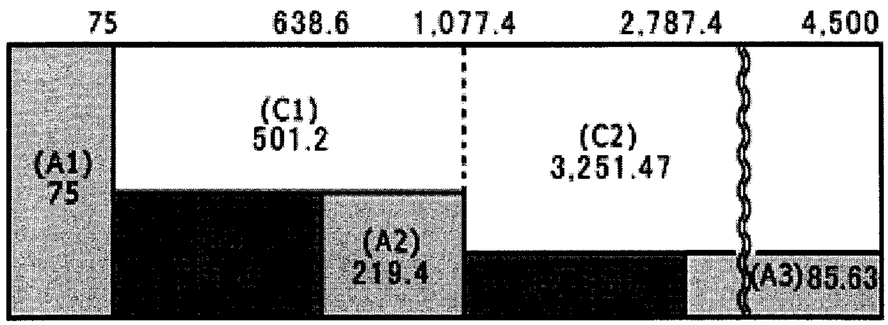
Source: The Public Private Sector Risk-Sharing in the French "Cat. Nat System" by Marcellis-Warin and Michel-Kerjan, November 2001.

The primary sources of funding for catastrophe pools are: insurance premium from the homeowners joining the system; reinsurance premium -in cases when pools act as reinsurers themselves, reinsurance coverage from their own reinsurers; pool's own surplus capital; assessments on private insurance companies; commercial backstop facilities, contingent credit lines, and direct government contributions in excess of programs' claims paying capacity.

Funding

In addition, over the last few years, some catastrophe insurance pools, such as CEA, have also obtained access to international capital markets by issuing catastrophe insurance bonds. Figure A 1.2 below provides an example of a mixed structure of funding for catastrophe risk for JEE.

Figure A 1.2: Japanese Earthquake Reinsurance Program



Liability of J.E.R.;(A1) + (A2) + (A3) = Y 75,000m. + Y 219,400m.+ Y 85,630m

Liability of private ins. and The Toa Re.; (B1)+(B2) = Y 281,800m. + Y 85,500m

Liability of Government; (C1) + (C2) = Y 501,200m. + Y 3,251,470m

Insurance Vehicle

In addressing the inherent underlying constraints of the domestic private insurance market in case of catastrophe insurance coverage, countries have opted for specialized direct catastrophe insurance or reinsurance vehicles. This choice in many respects has been predetermined by the development of the local insurance market and its willingness to retain any catastrophic risk underwritten by the program. A combination of the two approaches is also possible, with the Florida Hurricane Fund being the prime example. Currently, of the twelve catastrophe programs listed in Table A 1.3, four programs (FHCF, CCR, JER, and Norsk Naturskadepool) are designed around the reinsurance concept and in the remaining eight programs the government plays a very critical role by providing an "implicit" or an explicit guaranty to honor all claims against the pools, which in essence amounts to an excess of loss reinsurance contract.

Table A 1.3: Insurance Vehicles

Fund	Insurance Vehicle	Characteristics
TCIP/ EQC/ CEA/ HHRF	Insurance Pool	Lack of capacity on the part of direct insurers to underwrite Cat Risks.
FHCF/ CCR/ Norsk Naturskadepool	Reinsurance Pool	Reinsurance provided at both below market rate and with minimum volatility in reinsurance prices
JER	Insurance Company	Risk spreading among insurance companies who are shareholders of JER and also reinsurance capacity provided by the Government of Japan.

Coverages

While all the catastrophe insurance programs listed above offer coverage for buildings and usually contents, only one third covered the risk of business interruption. Several of the surveyed insurance programs also included emergency living expenses in the immediate aftermath of a disaster in their coverage.

While all programs offer personal catastrophe risk coverage, only a few cover commercial risks. One of the reasons behind such a strong focus of these institutions on providing residential coverage is their explicit social commitment to ensuring that adequate catastrophe insurance coverage exists for the population. Besides, commercial/ industrial risks as a rule are well covered even in the least developed markets and thus are rarely a subject of a public policy concern. Nevertheless, there is certainly scope for extending catastrophe insurance coverage provided by catastrophe pools to SMEs, which often are underinsured.

Rates

As the primary objective of most catastrophe insurance programs is to ensure the availability of affordable insurance coverage for homeowners, their premium rates for the worst risks tend to be capped at some level. Some programs, such as the HHRF and Norsk Naturskadepool, charge a flat rate irrespective of location or construction quality of covered properties; this of course takes the "solidarity" principle to the extreme and offers no mitigation incentives. While the advantage of having the flat rate is its administrative simplicity, the majority of programs charge variable rates that depend on a property's risk zone and the type of construction. All in all, about a half of the programs had risk based premiums and none are subsidized. On average, all programs appear to collect enough premium to cover claims and expenses.

Table A 1.4: Rates Charged and Mitigation Incentives

Fund	Rate	Mitigation Incentives
TCIP	Depends on the location of property.	Can refuse coverage for new construction that is non-compliant with the building code.
NatCat	9% of underlying policy (auto, fire) premium.	Insurance companies can refuse to extend the "natural disaster" guarantee to buildings built in high-risk zones and/or built in violation of administrative rules in effect at the time of construction. This encourages mitigation.
JER	5.0% to 4.3% of insured value, depends on location and construction type.	None.
Norsk Naturskadepool	Flat rate on insured values.	None.
Consorcio de Compensación	0.09% to 0.25% of insured value.	None.
TREIP	NT$1,459 per policy, flat rate.	None.
FHCF	Premium based on location, construction type. Premium remains constant but coverage level changes.	US$10 million earmarked for funding mitigation activities.
HHRF	US$1.50 per US$1,000.	Rate credits available for roof-wall and roof foundation clips and storm shutters.
CEA	Ranges from 1.1% and capped at 5.25%.	Depending on its date of construction, a house that has been retrofitted may be entitled to a 5% premium discount.

Voluntary vs. compulsory

Most of the programs are voluntary, with only three being compulsory or semi-compulsory (TCIP, FHCF, and JER). In the case of compulsory programs, compliance is generally low, with around 20 percent of insurable housing stock covered in the case of TCIP and JER. Yet, the level of insurance penetration achieved under the compulsory programs is undoubtedly considerably higher than under the programs with voluntary participation. In the case of India, for instance, where insurance coverage for natural disasters is optional, the insurance premium for natural disasters represents less than one percent of the total premium written.

Reinsurance

Catastrophic events are the greatest single threat to the solvency of insurers. Rating agencies generally require that insurers have enough capital to pay for at least a 100-year loss event. To attain the top rating, insurers may need to maintain enough claims paying capacity for surviving a loss from a 250-year loss event. Reinsurance is the traditional method used by insurers to boost their claims paying capacity, with capital markets becoming a growing source of reinsurers' own capacity.

A recent upward trend in reinsurance pricing (see Chart 2) has also spurred a series of reinsurance initiatives at various levels of sub-national and national governments. Since the insurance premium charged to property owners is, to a greater or lesser extent, a function of global reinsurance prices, some national governments are becoming more concerned with the availability and affordability of such reinsurance coverages.

While some programs such as FHCF, CEA, TCIP, HHRF, and Norsk Naturskadepool rely on private reinsurance markets for their reinsurance coverage, others are directly backed by their governments, as is the case with CCR. There are also cases when both private and government reinsurance capacities are used (JER).

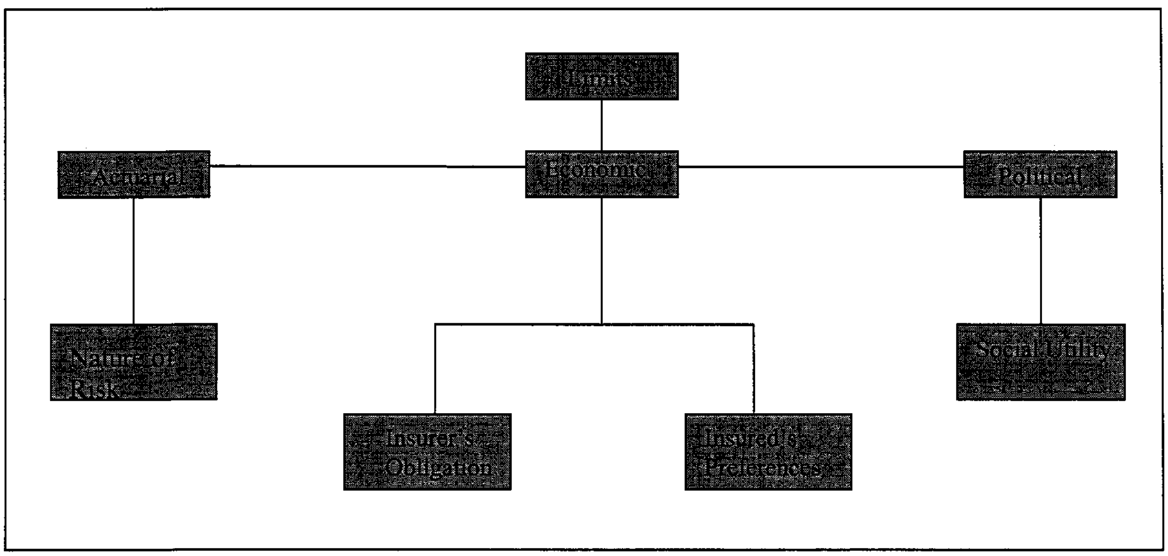
Another critical consideration in the design and management of a reinsurance program is the level of reinsurance to be purchased. This decision has an impact on the expected survivability of a catastrophe insurance pool, on the speed at which it would accumulate its surplus and on the affordability of reinsurance or insurance coverage it provides. For instance, despite being among the safest insurance programs in the world, CEA is one of the most expensive ones as well, as it has made a decision to maintain enough claims paying capacity for surviving a 1 in 800 year event. TCIP is on the other end of the spectrum as the least expensive catastrophe insurance program in the world, buying just enough reinsurance to survive a 1 in 170 year event, which is on the lower end of the investment grade scale for commercial insurers.

Appendix II: Insurance Market Economics

Insurance is an intangible and purchasers of insurance are engaging in an act of faith; they are giving up alternative current consumption to cover the small possibility that they will suffer a loss which is large enough to significantly destabilize their or their dependents' future consumption pattern. The purchasers of insurance must recognize and fear the potential for loss, not have attractive or easily accessible alternative means of dealing with that loss, and have a perception that the loss has a not insignificant chance of occurring. In addition, they must trust the insurance company to still be in existence when a claim occurs and to handle the claim fairly. Finally, the cost of insurance should not involve a significant reduction in current consumption. For many these conditions do not exist and insurance is seen as a deadweight cost if no loss occurs.

In addition, the market must be prepared to provide the service at a price which is less than the consumer's assessment of the value of removing the risk, if a market clearing equilibrium is to exist. Another necessary condition is that the relevant actuarial and socio/ legal infrastructure has to be in place. A general model of this framework has recently been developed by Vate and Dror (Figure A 2.1).[81]

Figure A 2.1: The Limits of Insurance Markets



The actuarial conditions are the best researched and require that the risk should appear to be random and thus not subject to the influence of the insured, except possibly in a mitigating sense (for which the insured would ideally be rewarded). In addition, the insurer's aggregate retained risk should not have characteristics that invalidate the law of large numbers and the central limit theorem (for example, having a non-infinitesimal probability of generating large losses relative

[81] Vate. And Dror (2003).

to premium income and capital) and should be definable and measurable to the satisfaction of those pricing the contract.

Most models in insurance economics assume that the consumer is primarily motivated by a desire to reduce the chance of lost future consumption (including shelter) according to a concave utility function and possibly a distorted assessment of the probability of loss. These models also assume that the insurance provider prices at a level to cover input costs, including allowances for the cost of the capital required, which in turn is assumed to be sufficient to reduce the probability of insolvency to an acceptable level. These respective pricing algorithms may or may not lead to a market clearing price (Box 2.1).

Political determinants of insurance consumption revolve around issues of culture (including religion), property rights and rights of redress, the definition of public goods and the role of the state and of alternative risk management techniques. Until recently the state owned the major insurance and reinsurance activities in many countries, and this tended to restrict innovation and ultimately the energy applied to growing the insurance markets. While the actuarial and economic limits on the definition of insurability have been gradually expanding in many industrial markets, insurance law is often not only out of date and highly restrictive in developing markets but also tends to favor the insurer over the insured in the event of a dispute.

In addition to the factors already mentioned, it appears that human beings are not consistent in their assessment of different types of risk, or over time, and tend to place different weights on severity and probability when determining their level of risk aversion. A recent econometric study of subsidized flood insurance in the United States indicated that the existence of a recent event is an important determinant of the willingness to buy.[82] This is consistent with many similar studies of multi peril crop insurance. The role of price is less obvious: non-life insurance appears to have some of the characteristics of a normal good as opposed to life insurance, which is clearly a luxury good.[83] For example, the flood insurance study cited earlier indicates that the demand for flood insurance contracts is relatively insensitive to price changes, but that the amount of coverage purchased is sensitive. Grace and others (2002) found evidence that the demand for catastrophe insurance has greater elasticity relative to price than normal householders coverages.

These studies are mostly relevant to industrial societies, where insurance tends to go with credit creation and it could be argued that they are not applicable to poorer communities. However, studies and anecdotal evidence point to a strong desire to manage risk even amongst the poor and a willingness to sometimes pay heavily to use whatever mechanisms are available. Micro-insurance in particular is a growing phenomenon and a number of experiments on various continents appear to be showing some promise, although it is still early days. Even the poor, however, demonstrate differing approaches according to the nature of the risk concerned, with impact on earning ability and the perceived ability to control the risk being important considerations. For example, one study shows that in Cambodia farmers are more risk averse to loss of health (and will thus buy stand alone insurance) than they are to loss of livestock, the other major potential catastrophe.[84] Other studies have shown examples of market failure for the

[82] Browne and Hoyt (2000).
[83] Lester and Galabova 2002.
[84] Brown et al. (2000).

poor in industrial countries, which have in some cases led to government intervention in markets.[85]

Box A 2.1 – Insurance Market Economics

The consumer is assumed to value a unit of increased wealth less than a unit of decreased wealth (the classic utility assumption). In addition in the latest models a separate risk aversion model (based on different perceptions of the cumulative loss probability, which is assumed to be independent of the utility curve) is determined. The combination of these two curves determines the propensity to consume insurance. As would be expected, the lower the premium rate and the greater the level of pessimism relative to the real probability loss distribution, the greater the desire to purchase insurance.

The price at which the insurer or reinsurer will offer a risk transfer contract is based on the expected loss plus an adequate expense loading plus a loading for the overall cost of capital at risk. Capital in turn is a function of individual loss variability and correlation, the size of the portfolio, parameter uncertainty and model uncertainty.[86] An alternative, somewhat more operational formulation uses the concept of a safety coefficient, below which an insurer will not accept risk.[87] This again determines the price at which the institution is prepared to accept business and hence the possibility of an equilibrium.

Safety coefficient = (Capital + aggregate risk loading)/individual standard deviation*√Number of risks

This latter formulation demonstrates that if capital is in short supply then the only alternatives are to increase the number of insureds or to modify the risk through reinsurance (if the price is economically attractive) or to engage in more selective underwriting.

The situation in developing countries has often been exacerbated by the way in which insurance markets have developed. Typically insurance is first consumed by the major industrial enterprises, often under pressure from international partners applying modern risk management techniques (airline hulls and liability are the classic example). Government and semi-government infrastructure sometimes follow (although with varying degrees of efficiency), and finally the inevitable growth of motor car fleets usually leads to compulsory personal third party liability insurance. Often personal business and particularly compulsory insurance is handled badly, with slow and sometimes corrupt claims handling, which creates the impression that it is a tax (at best) or an opportunity for graft by government employees and others (at worst). Either way, personal lines and small business insurance have in many developing countries gotten off to a bad start in comparison with the development of insurance markets in most industrial countries over the last 200 years.

[85] See, for example, Peacock et al. (1997).
[86] The impact of uncertainty on reinsurance pricing can be substantial – see Froot (1999).
[87] See Vate and Dror, ibid., page 150, for the theoretical basis of this formulation.

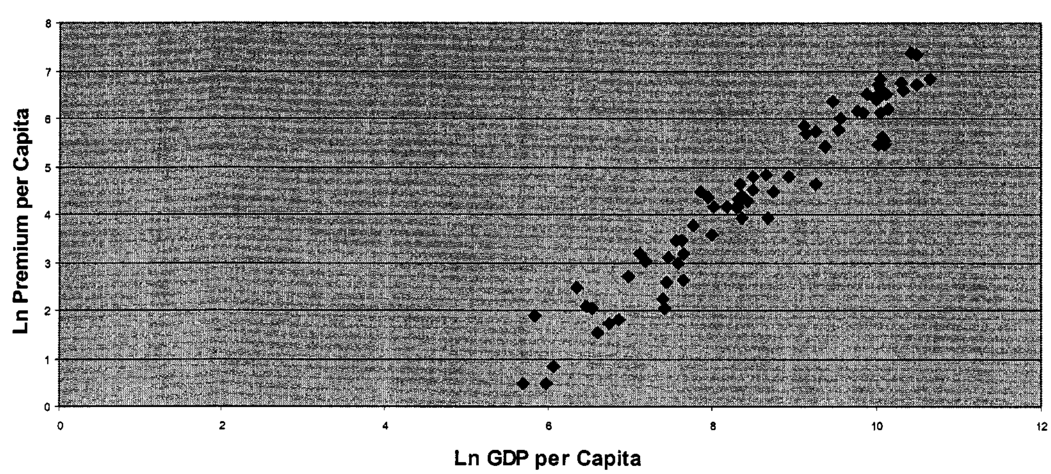
Table A 2.1: Insurance Market Development Paths

Industrial	Developing
• Friendly society, farmer mutuals – full trust from day one. • Steady evolution – large mutuals, industrial insurance, government insurers • Demutualization, market conduct law, privatization	• Compulsory motor insurance • State insurers subject to non-market influences • Poor claims paying record • Seen as tax • Poor regulation, no recourse • Loss of trust

Given the limitations on data plaguing the insurance sector, the most useful aggregate measure of consumption at the country level is found by charting insurance consumption per capita against GDP per capita; these data have been recorded by Swiss Re for many years. If logarithmic charts are used, an immediate snap shot indication of the elasticity of insurance consumption relative to economic growth is produced (Chart A 2.1).

This points to a global elasticity of approximately 1.3 for non-life insurance (countries subject to Sharia law have been removed from the database because of their particular and still evolving approach to insurance). In other words a 1% increase in GDP per capita is roughly matched by a 1.3% increase in premium spending per capita. Outliers on the low side include the higher income countries where strong social insurance systems are provided through state mechanisms (mainly the Scandinavian countries), and a number of Asian countries, including India for reasons discussed earlier. Outliers on the high side tend to be industrial countries with strong and litigious liability environments or developing countries with long histories of private market development.

Chart A 2.1: Non Life Insurance Elasticity of Premium per Capita vs. GDP per Capita



Appendix III: Hazard And Vulnerability Models

Hazards

Earthquake Hazard Model

A seismic risk assessment of two states, Maharashtra and Gujarat, was conducted for this report, which involved the compilation of an earthquake catalog, identification of seismic sources, generation of stochastic events and computation of site-specific ground motion. Most of the input data came from secondary sources such as published research undertaken within the country by its premier educational and research institutions. In addition, reputable international sources were used as necessary.

As part of the calibration model and validation of the model, scenario analyses of the most recent catastrophic events in the region were undertaken. The modeled and observed isoseismals were then compared.

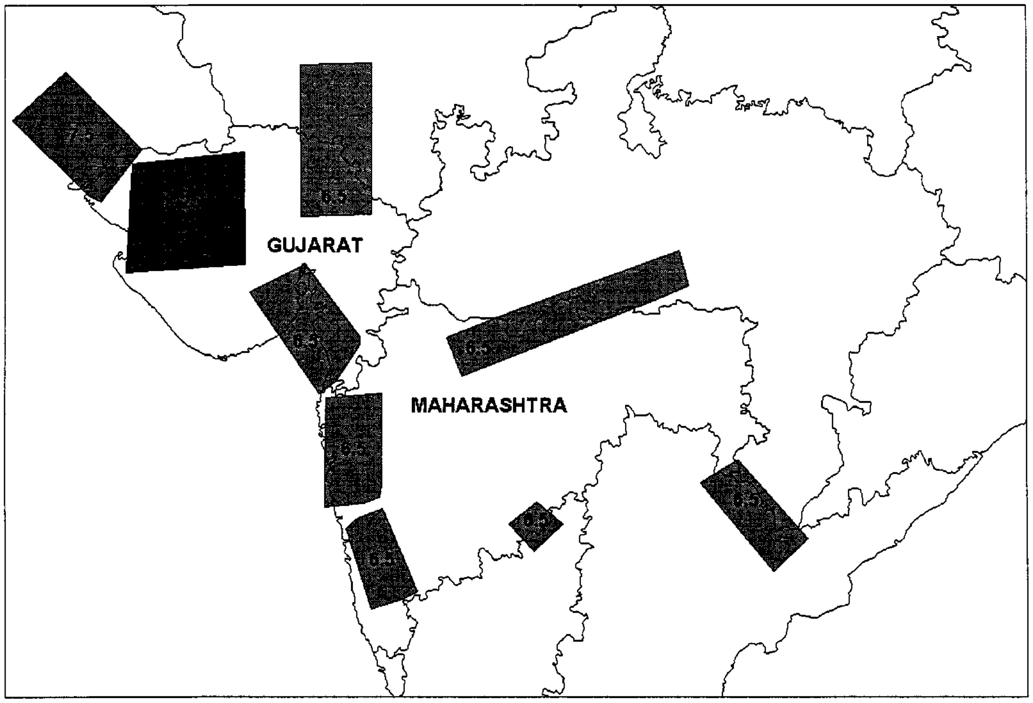
Historical earthquake catalog: The historical catalog compiled by RMSI serves as the basis for the earthquake model. The major source for this catalog is the one published by ISET.[88] This catalog covers a period dating back from the history up to 1979. To meet the requirements of the present model, a new catalog was compiled taking ISET catalog as the starting point. The data beyond 1979 and up to the year 2001 were augmented using other sources, including USGS and NOAA.

Study of tectonics: To gather informed data on geology and fault system of the area, the seismo-tectonics of the regions under consideration were reviewed using existing seismic zonation in the published research papers, Indian codes and technical journals. The fault and geological data was obtained from the Seismotectonic Atlas of India[89]. The data from the atlas was processed to prepare a detailed map of the active faults in the region.

Seismic sources: Seismic sources are geographical areas that have experienced seismic activity in the past and serve as potential sources of earthquakes in the future. Seismic sources are delineated based on tectonic or geophysical features and homogeneity of seismic activity. For each seismic source, past earthquake activity was assumed to be a reliable predictor of future activity. In a study carried out under GSHAP, eighty-six seismic sources were identified for developing the predictive model for India. The present model adopts the findings of the study and considers only those sources falling within the boundaries of the two states of interest and also within a 200 km buffer outside the state boundaries. The selected sources and along with the maximum magnitude in each source are shown in Figure A 3.1.

[88] ISET, "Catalogue of Earthquakes in India & Neighbourhood," Roorkee (1983).
[89] GSI, Seismotectonic Atlas of India and Its Environs, Calcutta (2000).

Figure A 3.1: Modeled Sources with Maximum Magnitudes



The sources identified above are modeled by a series of line sources of uniform seismicity distributed evenly within the area source. The total seismicity of the component line sources is equal to the seismicity of the entire area source. Orientation of the line source is done with respect to the main fault within the area source. The various events in the catalog were assigned to the sources chosen for the analysis on a one-on-one basis. Small size events (called floating earthquakes) that could not be associated with any major source were assigned to "background" sources. Two background sources were delineated, each fully covering a separate state.

Earthquake rates of occurrence: Once the seismic sources were defined, it was assumed that future activity would be limited to those seismic sources and follow a pattern similar to past activity. The Poisson model is the most common way of representing the seismic activity of an earthquake source. The basic assumption of the Poisson model is that the parameters governing earthquake occurrence are independent of time, magnitude and space. In other words, the model considers how often events occur on the average (average rate of occurrence) and treats the probability of future earthquakes as independent of any previous earthquakes. The input required for this model is the average rate of occurrence of each magnitude of interest. The average rate of occurrence of earthquakes is commonly estimated using an exponential distribution for earthquake magnitude (the ratio of the number of small events to the number of large events) expressed as a relationship between the frequency and magnitude of earthquakes.

This relationship, often described as the Gutenberg-Richter relationship, is given by the following equation:

$$\text{Log } N = \alpha + \beta M$$

Where N is the cumulative number of events greater than magnitude M and α and β are based on a regression analysis. For each source, the constants α and β of the recurrence relationship are obtained by a regression analysis of the historical record of earthquakes.

Ground motion: The majority of damage caused by earthquakes, especially to buildings, can be directly attributed to the effects of ground shaking induced by the passage of seismic waves. The estimation of the ground shaking expected at each location is therefore fundamental to the calculation of the resulting losses. Once the parameters of each earthquake in the stochastic set are defined, the intensity of ground shaking is calculated for each earthquake at each location of exposure. The intensity of an earthquake is modeled from:

- the attenuation of the ground shaking intensity, which depends on its magnitude, depth and earthquake mechanism; and
- the local modifications to the shaking that are caused by the prevailing soil conditions.

For a given earthquake, the attenuation, or rate of decay, of peak ground acceleration (PGA) was estimated from the epicenter to the site of interest based on the Joyner and Boore (1993-1995) attenuation equation.

PGA to MMI conversion: Once the PGA had been obtained, it was converted to Modified Mercalli Intensity (MMI). The MMI is a measure of the local damage potential of the earthquake. For the same PGA, distant earthquakes have longer duration and lower frequency content than nearby earthquakes and are therefore more damaging. Limited studies were performed to determine the correlation between structural damage and ground motion in the region. To convert PGA to MMI , the present study employs Trifunac – Brady's relationship modified while calibrating with recent events.

Local soil correction: Local soil conditions can significantly impact earthquake ground motion and resulting structural damage. Soil maps were procured from NBSS&LUP and processed to arrive at the soil classes and shear wave velocities within the region of the two states. The MMI at block centroid was then corrected for the local soil effect.

Validation: The PGA/ MMI values were computed for some of the historical events at the centroids of the blocks to calibrate and validate the hazard model. Comparisons between observed and modeled MMIs are given in Tables 1.4 and 1.5 in Annex I for the 2001 Bhuj earthquake in Gujarat and 1993 Latur earthquake in Maharashtra.

Cyclone Hazard Model - The model is based on a stochastic module consisting of thousands of simulated events representative of the characteristics of the historic storms. The complex cyclone model comprises three separate, but related, sub-models: 1) a wind model, 2) a storm surge model and 3) a rainfall model. Each of the three will produce a hazard that can be viewed separately from others. However, their combined effect is a subject matter of the vulnerability model. The following three states were considered for cyclone modeling – Andhra Pradesh, Orissa and Gujarat.

Historical cyclone catalog: A historical cyclone catalog is available for the period 1891 – 2000. However, information on central pressure, wind speed and bearing at every 6-hourly time-steps is complete only for the period 1956 – 2000, a substantially shorter period than is ideally desirable.[90] The catalog was compiled by RMSI based on data and information published by IMD, NCDC, JTWC and other international sources. The compilation process involved sourcing, cleaning and filling the gaps by informed judgment.

Line gates: Depending on location of initial landfall of the historical storms and orientation of coast, coastal gates/segments were set up accordingly. These are line gates of the same size, approximately 50 nautical miles (NMi) in length, following the coast closely.

Rates of occurrence: The annual rates of occurrence of historical storms were calculated at each gate as a ratio of total number of storms to a time window of historical data. The rates are smoothed at each gate to account for those gates where there was no storm in history.

Cumulative distribution functions (CDF): Based on the landfall data given in the catalog, the probability distributions of the cyclone parameters like central pressure, forward speed and track angle were then defined. For each of the parameters, the CDF was generated separately for each of the states. These distributions were then sampled during the simulation process to generate stochastic events. Once the rates and distributions had been finalized (referred to as targets), the CDFs were divided into bins for random sampling.

Stochastic events: From each of the bins, using a uniform random sampling technique, an equal number of random samples were drawn for all the parameters and each sample variable was assigned an individual probability. Using random numbers, each simulated or stochastic event was associated with a central pressure, forward velocity and track angle. The landfall location of the event was assigned randomly at a gate.

Radius to maximum winds (Rmax) was assigned based on central pressure derived from a study by Bell (197) of Western Pacific basin cyclones as this basin has similar characteristics to the North Indian Ocean. So, a stochastic event at landfall is finally defined by central pressure, forward speed, track bearing, landfall latitude, landfall longitude and Rmax.

Pattern matching: Each stochastic event was then matched with a historical event using a pattern recognition technique for its track and filling rate. The historical events were translated and rotated around the coastline to reflect the characteristics of stochastic storms. The filling rate was verified by equations given by Kaplan and DeMaria (1995).

The number of storms required in the model was worked out experimentally to obtain the model's fit to the targets and loss convergence.

Wind Model - The gradient wind field for stochastic events is defined by Georgiou's equation and surface wind field is based on calibration from key historical events.

Roughness: The land use and land cover (LULC) data for the three states were derived from high-resolution 25-meter remote-sensing data available with RMSI. Based on the land use, the roughness values were assigned with the help of the classification given by Cook.[91] The roughness data and assessment of roughness change with direction were aggregated at block

---

[90] The relevant statistical rule of thumb is that to estimate the return period of an event, given a stable process, requires 5 to 10 times the length of the return period.

[91] N.J.Cook (1986).

centroids (as per the methodology in Cook (1986), chap.9). A simple tool is written to implement the methodology, which entails an aggregation of 8 or 12 directional roughnesses over a circular spread of 200 km.

Topography: Topographical features are not considered in the model as the terrains under consideration are nearly flat.

Gust factor: The gust factor was determined based on the local turbulence (local roughness, per Cook methodology).

Site Coefficient: The site coefficient is calculated as multiplication of roughness factor and gust factor.

Historical storms reconstruction: The important historical cyclones are calibrated using the available stations' data. The gradient height wind speed was determined using Georgiou's equation (1985).

Based on the available data of surface wind speeds, the relation between the gradient wind speeds and the surface wind speeds was worked out using regression analysis.

Stochastic storms: A tool in Excel was developed to generate the windfield for the stochastic storms. The windfield of cyclones was computed using a simple windfield model, which entailed the following three-step approach:

A. The gradient wind speed is obtained from Georgiou's equation as given above.
B. Surface wind speeds are determined from gradient wind using the relationship arrived at from the historical analysis.
C. Surface wind speed was converted to Peak gust using following relation:

$$\text{Peak gust} = Vs * \text{Site Coeff}$$

Storm Surge Model - A nomogram-based surge model developed in India was adopted to compute the storm surge height along the coasts of three states - Andhra Pradesh, Orissa and Gujarat. For a landfalling storm, surge height was computed taking central pressure, Rmax, forward velocity and orientation of the track as the inputs.

Methodology: In the first step, a preliminary estimate of the peak surge height S_P is obtained from the nomogram of peak surge for different pressure drops (DP) and radius of maximum wind (Rmax) for a standard basin and standard storm motion (storms crossing normal to the coast). In the second step, correction factor F for the bathymetry was obtained from the nomogram of shoaling factors. To correct for the effect of a non-standard storm track, a factor F_M was obtained from the third nomogram of vector storm motion. The product of S_P, F and F_M obtained from the first, second and third nomograms respectively give the final corrected estimate of the peak surge at a location. The mean astronomical tide is added to the peak surge height to estimate the surge tide at coastal locations. The surge tide at the coastal location is attenuated with distance inland to estimate the surge tide at inland location using the attenuation function. The difference between the surge tide and the elevation of the location inland gives the flood depth.

Rainfall Model - Rainfall associated with a tropical cyclone is dependent on its size, forward speed, direction and intensity. Rainfall is directly related to a storms' size and inversely related to its speed, i.e. slower moving storms yield more rainfall at a point than faster moving storms and large sized storms produce more rainfall than relatively small sized storms. For cyclones of Indian Ocean origin, it has been observed that rainfall is more in the left forward sector for the westerly moving cyclones, in the forward sector for cyclones moving in a northerly direction and in the right forward sector for cyclones heading in a northeasterly and easterly direction (Mandal, 1990).[92] However, this is a generalized picture of rainfall distribution around a cyclone and the pattern can vary significantly from cyclone to cyclone. To overcome this rainfall variability from system to system and to obtain a general picture of rainfall distribution around the cyclone of different intensities, the compositing of rainfall suggested by Frank, whose methodology for rainfall estimation is based on a study of 87 US hurricanes in the Atlantic.[93] The key parameters of that model are (i) hourly precipitation rate; (ii) translational speed and, (iii) size of the cyclone.

The above parameters were considered to model the rainfall distribution of tropical cyclones in the Indian region as well. The hourly precipitation rates were computed considering a study of rainfall distribution around tropical cyclones in the Indian seas by Jayanti & Sarma by compositing rainfall data.[94] The study considered 270 pre monsoon and post monsoon cyclonic disturbances of different intensities. The study observed that for cyclones making landfall along the east coast, the maximum rainfall concentrated in a circular region of 50 km radius with a significant rainfall region extending up to 200 km. Beyond 200 km and up to 500 km rainfall is observed to be too insignificant to cause any damage or to contribute towards flooding. To keep things simple, significant rainfall region is assumed up to 300 Km from the center in the present model. Jayanti's study has provided the rainfall rate of tropical cyclones in three stages based on wind speed. All cyclones with wind speed greater than 47 knots were clubbed in one category. This drawback has been removed by considering the rain rate associated with different stages of tropical cyclones of higher intensity. For this purpose, Frank's study has been taken to consider proportionate rate of rainfall associated with high intensity tropical cyclones (Suffir Simpson's Cat 1+2 and Cat 3+4+5) over the Indian region.

Rainfall is estimated at block centroid at hourly interval of storm progress for the period the area is affected by significant rainfall zone (300 km annulus circle). To compute the total rainfall for a block, the rainfall associated with each time step is finally integrated over the exposed area of the block for the significant rainfall duration.

Validation: The model is validated against historical events wherever observed values are available for wind speed, rainfall and storm surge. (Wind model results of peak gust wind speeds are compared in Tables 1.6 and 1.7 (in Annex I) for two famous historical events – the 1977 cyclone of Andhra Pradesh and the 1999 cyclone of Orissa, and indicate the problems in capturing the idiosyncratic nature of this hazard).

Flood Hazard Model - As mentioned earlier, the scope of flood analysis is limited only to riverine floods, which cause most of the flood damage. Flooding due to cyclonic storm surge along the coast is modeled separately and inland flash floods are excluded. A comprehensive

---

92 G.S. Mandal (1990).
93 W.M. Frank (1977).
94 N. Jayanthi and A.K.S. Sarma (1987).

river flood model would include all components from rainfall to runoff to river flow to flood inundation. However, considering the nature of the study and the constraints of available data the modeling scope was limited to river flow to flood inundation.

Methodology: U.S. Army Corps of Engineers' software package "Hydrologic Engineering Center - River Analysis System" (HEC-RAS) (version 3.0.1) for floodplain mapping was used for analyzing the flood prone areas including flood-protected areas.

The stepwise procedure is outlined as follows:

1. Fit Gumbel's extreme value probability distribution to the historical annual peak discharges observed at a gauging station.
2. Annual peak discharges for different return periods were calculated. The return periods taken are 5, 10, 50, 100, 500 and 1000 years. These are the stochastic events for the model.
3. HEC-RAS is run for each of the stochastic discharges to obtain water surface profiles along and across various reaches of the river network. Suitable assumptions were made with regard to Manning's roughness coefficient, distribution of flood flow rates in each of the channels, initial conditions and boundary conditions to carry out the computational runs.
4. Using the block boundary map and DEM/TIN as inputs, average depth over block and extent of flooded areas were obtained by post-processing the HEC-RAS results in ArcView GIS software.

Data Requirements: The data used in this project were classified into three types: hydraulic, hydrologic and spatial data.

Hydraulic data: Steady 1-D flow models require at a minimum, three forms of hydraulic data: 1) stream geometry, 2) streambed resistance factors, and 3) flow/stage boundary conditions. The river network is taken from the topographic maps and cross sections are extracted from TIN. Stream cross-sections along the network make up a significant portion of the overall geometry data. Bed resistance factor is taken as Manning's n. A value of 0.35 is assumed for the main stream and 0.1 for the flood plains. Peak flow data at river gauging stations is taken from the publications of UNESCO and CWC to the extent available.

Hydrologic data: Since the model addresses river flow to flood inundation process only there is no hydrologic data was required.

Spatial Data: Visualization of floods in ArcView GIS required a detailed representation of the terrain to accurately depict flood inundation. DEM (Digital Elevation model) or TIN (Triangular Irregular Network) can be used to develop the terrain model. TIN was used in this model for better representation of the terrain and was extracted from topographic data.

Validation: A detailed validation at the hazard level was not undertaken due to lack of detailed hazard data of historical events. For example, data on flood depths at different locations and extent of flooding are required to validate the results of the model which is not available even for one historical event. The model was only validated for flood depth at the gauging station given the discharge of the historical event at that point. However, detailed validation was undertaken at the loss level based on the available extensive historical loss data.

Assets at Risk - The exposed assets considered in this study fall broadly under public and private domains, with the latter consisting only of residential dwellings. As to the public assets, the following infrastructure elements were considered:

1. Educational institutions: schools and colleges
2. Medical facilities: hospitals and health centers
3. Roads and bridges

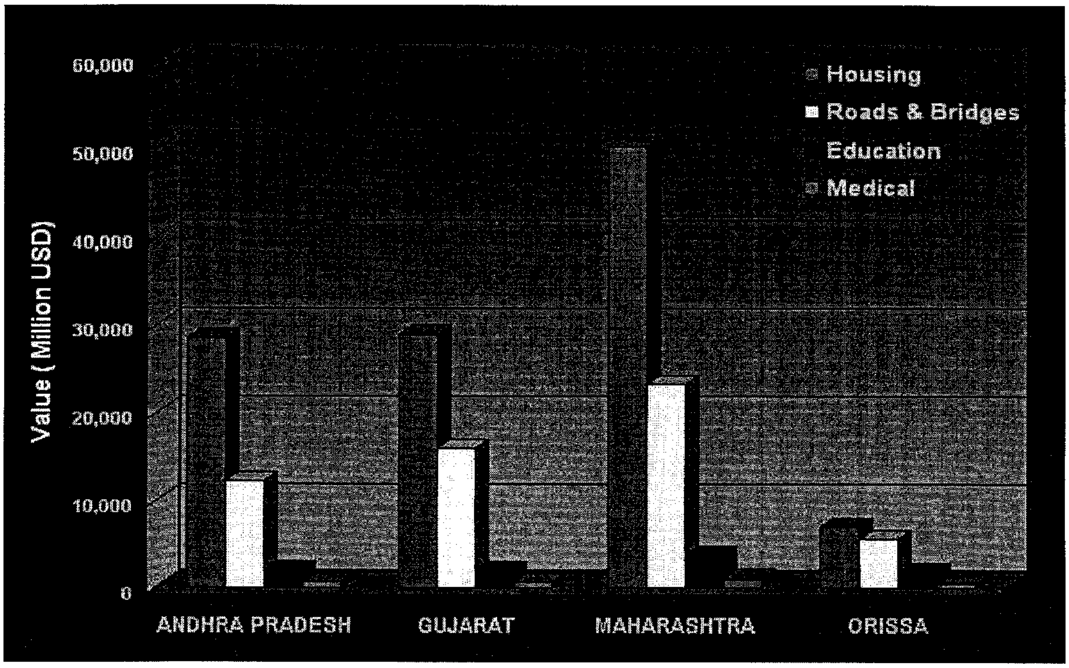
Exposure was calculated in terms of replacement cost in dollars at 2002 prices. The distribution of exposure by block, by district and by asset class can be obtained from the main study. A quick comparison of the exposures from all perils in the four states is given in Table A 3.1 and the same is illustrated in Chart A 3.1.

Table A 3.1: Exposure Value Summary (US$ Million)

	Combined	Private	Public infrastructure			
	Assets	Housing	Total	Education	Medical	Roads & bridges
AP	43,444	28,521	14,923	2,022	666	12,235
GJ	47,451	28,887	18,564	1,939	645	15,980
MR	78,141	50,158	27,983	3,639	1,089	23,255
OR	15,059	7,018	8,041	1,915	464	5,662

Source: RMS Delhi

Chart A 3.1: Exposure Value Summary (US$)



Housing has the highest exposure followed by roads and bridges, education and medical. This trend is consistent across the four states, except in Orissa, as housing accounts for over 60% of the total exposure for the selected states. The low values of housing and infrastructure exposures in Orissa compared to other states can be explained by its smaller population, a lower level of economic development and, thus of the exposed asset base. Maharashtra clearly stands out in terms of exposed value for all asset classes.

Consistent with worldwide experience, India has large concentrations of population along the coast that are highly vulnerable to the risk of a cyclone. The results of the cyclone hazard model suggest that wind speed, rainfall and storm surge are maximum along the coast. While maximum wind speeds prevail in the districts along the coast, storm surges dominate the coastal blocks. In Andhra Pradesh, 44% of housing value lies in the nine coastal districts from Nellore to Srikakulam, which are highly exposed to cyclones. In Orissa, 27% of housing value lies in six coastal districts from Ganjam to Balasore. However, once the proximity of the districts Gajapati, Khurda and Cuttack (a part) to the coastline and thus to cyclones is taken into consideration, the value of housing stock exposed to potential loss goes as high as 47% in Orissa. Finally, in the state of Gujarat, two-thirds of housing assets are in the coastal districts.

Methodology: Assessment of exposures at block level for buildings and other assets in India has been a challenge due to the lack of detailed primary data. As a result, the exposure values at block level were estimated either from available secondary data sources or derived from the distribution patterns of population at a district and block levels. The methodology for quantifying risk exposures for the selected states involved extensive literature surveys and site visits to the states of Orissa and Andhra Pradesh to carry out data collection and ground validation of the model assumptions. The values for all types of exposures were derived as the value of inventory times the average cost per unit.

The floor area and unit cost estimates were made based on information available in event reconnaissance reports, reconstruction reports and from the ground validation exercises. To estimate the cost per unit of floor area, cost information from the public works department was used as well. The results of these calculations along with the floor area and the unit costs used to calculate the Andhra Pradesh housing exposure are tabulated below:

Table A 3.2: Housing Replacement Cost (Rs)

Building Wall Material	Floor Area (Sq.ft.)	Cost / Unit area (Rs Per Sq.ft.)	Cost / Census house (Rs)	Cost / Census house (US$)
Mud / Unburnt brick	180-250	50-80	10,000	204
Stone	250-450	100-175	33,000	673
Burned Brick	575-1200	250-350	200,000	4,082
RC	750-1500	350-450	415,000	8,469
Others (Wood, Light Metal, etc.)	180-250	50-80	14,000	286
Average Census House			90,000	1,837

Vulnerability

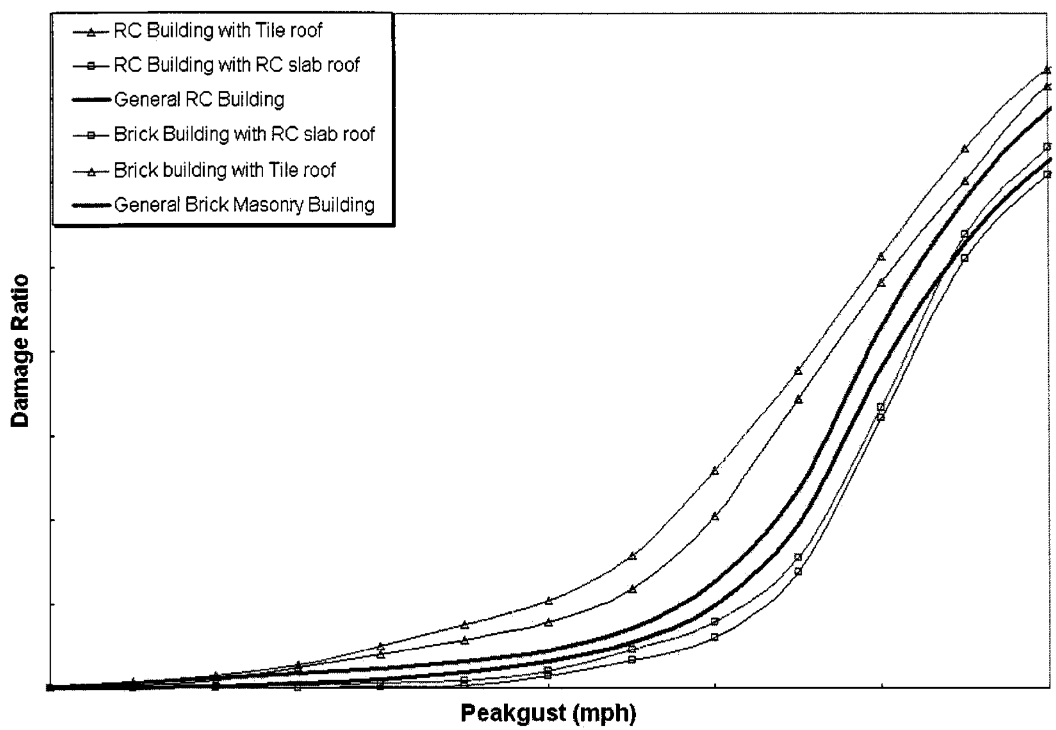
To determine the degree of loss to housing and infrastructure resulting from exposure to a hazard of a given severity, the study developed vulnerability functions covering the four states of Andhra Pradesh, Gujarat, Maharashtra and Orissa. An outcome of this work is a set of vulnerability functions for different hazards which show how structural damage varies with exposure to different levels of hazard such as ground motion, wind speed or flood. This section provides a brief summary of this work.

Methodology: Methodology adopted for the vulnerability modeling is based on available loss/ inventory data complemented by engineering judgment and competent engineering and actuarial analyses. Development of loss functions for buildings and other exposures in India poses several challenges. The low availability of sufficient loss data and presence of large numbers of non-engineered structures makes the task of estimating vulnerability functions highly challenging.

Earthquake vulnerability: The vulnerability relativities between different classes of buildings were derived based on comparison of performance during past events (mainly the 2001 Gujarat earthquake), seismic base shear coefficients, construction quality, etc. In general, for buildings, age and height parameters were omitted to simplify the vulnerability model. However, the building vulnerability functions were modified to account for high-rise apartment structures prevalent in major cities. In case of roads and bridges, the vulnerability relativities between different classes of roads and bridges were derived based on comparison of performance during past events (mainly the 2001 Gujarat earthquake), construction quality and relevant engineering studies such as HAZUS.[95] The final curves for both residential construction and infrastructure were validated against the 2001 Gujarat earthquake loss data.

Cyclone wind vulnerability: The vulnerability relativities between different classes of buildings were derived based on a component-based methodology. The relativities were further improved upon by incorporating information on performance of structures during past events (mainly the 1999 Orissa Super Cyclone) and construction quality. In general, for buildings, age and height parameters were omitted due to non-availability of detailed data. However the building vulnerability functions for high-rise buildings were modified to account for their prevalence in major cities. The final curves were validated against loss data for the 1977 and 1990 Andhra Pradesh cyclones and the 1999 Orissa super cyclone. Vulnerability functions for RC and Brick buildings with different roof types and the respective general vulnerability functions are shown in Chart A 3.2. It was assumed that roads and bridges are unaffected by winds during a cyclone.

Chart A 3.2: General Building Vulnerability Curves



Storm surge and rainfall vulnerability: To avoid double counting of losses due to wind, surge and rain sub-perils, the cyclone model assumed that surge and rain perils affect only that part of a structure left undamaged by the preceding winds. Also between surge and rain, surge affects a structure before rain. For loss validation purposes, the surge and rain losses due to cyclones were segregated from the overall loss figures by making reasonable and logical assumptions. The vulnerability relativities between different classes of buildings were derived based on

[95] FEMA's Standardized Earthquake Loss Estimation Methodology.

information from engineering studies, performance during past events and construction quality. In general, for buildings, age and height parameters were omitted to simplify the vulnerability model. It was also assumed that rainfall-induced damage is caused by post flooding only. Also both intensity and duration of rainfall have been accounted for in the vulnerability model. The model assumptions used for infrastructure, wherever relevant, were similar to the buildings section described above.

Flood vulnerability: The vulnerability curves based on depth of flooding and vulnerability relativities between different classes of buildings were derived based on comparison of performance during past events and construction quality. Similar model assumptions for infrastructure were used. The final curves were validated against loss data for the 1986 Godavari (Andhra Pradesh) flood event.

Appendix IV: Eleventh Finance Commission: Chapter ix – Calamity Relief

CHAPTER IX

CALAMITY RELIEF

9.1 Para 7 of our terms of reference requires us to review the existing scheme of Calamity Relief Fund (CRF) and to make appropriate recommendations thereon. The scheme, introduced by the Ninth Commission (Second Report), is designed to enable the States to manage and provide for calamity relief on their own by drawing upon the resources available with a fund constituted for that purpose separately for each State. The prescribed annual contributions to each State CRF are required to be made by the Centre and the concerned State in the proportion of 75:25. The scheme further provides for an accumulating balance with the proviso that if there is any unutilised amount left at the end of five years , it would be available for augmenting the plan resources of that State. On the other hand, it is permissible under the scheme to draw upon a percentage of the next year's Central assistance, if it became necessary to tide over the insufficiency of resources in the CRF in any particular year. The CRF dispensed altogether with the requirement under previous calamity relief schemes of maintaining 'Margin Money', submitting a memoranda to the Central Government for determining the ceiling of approved expenditure (which entitled the States to the Central assistance) and receipt of assistance in the form of loans and grants. The Centre's contribution to the CRF of a State is now entirely in the nature of a grant.

9.2 While recommending the constitution of a CRF, the Ninth Commission noted certain deficiencies in the existing scheme. They thought it tended to encourage the States to present inflated claims with the expectation of receiving a higher Central assistance. Moreover, the arrangements in the wake of a calamity were far from satisfactory. Further, to overcome the procedural delays in sanctioning, releasing and deploying the assistance for carrying out the actual relief works the Ninth Commission recommended the constitution of a CRF from which the concerned State could draw funds as the need arose for the same.

9.3 In determining the size of the CRF and the annual contributions to it the Ninth Commission followed more or less the same basis as adopted by the previous Commissions. It took the State-wise average of the ceilings of expenditure approved during the ten years ending 1988-89 as the amount which should be available for relief in the respective States. The total of all the States aggregated to Rs.804 crores. If any region faced a calamity of 'rare severity' the Centre was expected to take appropriate action as the situation demanded and incur the necessary expenditure. The Commission did not define what constituted 'rare severity'.

9.4 Most States have expressed themselves in favour of continuation of the existing scheme, albeit, with some modifications here and there. Jammu and Kashmir, Nagaland and Tripura have pleaded that they should be completely exempted from making any contribution towards the CRF. Assam has stated that deficit States should be exempted from making any contributions to CRF and Madhya Pradesh has suggested total exemption for backward States. Orissa, Arunachal Pradesh and Himachal Pradesh have suggested reduction in the share of States from 25 per cent to 10 per cent. A number of States have asked for adjustment for inflation. Gujarat has stated that the amount provided as CRF should be adjusted for inflation over the last ten years and of subsequent years within the time frame of the Tenth Commission. A similar plea has been made by Rajasthan. Rajasthan also joins Madhya Pradesh, Maharashtra, Gujarat and Kerala in suggesting that the actual expenditure, and not the approved ceilings, should be taken into account for working out the size of the CRF . Mizoram is more specific and has pleaded that all expenditure incurred in connection with natural calamities and not only those booked under the Major head "2245-Natural Calamities" should be taken into account. Tamil Nadu has stated that it was not correct to determine the annual CRF on a historical basis according to the expenditure ceilings approved by the Centre in the period 1979-80 to 1988-89, as this historical trend failed to take note of the current price levels.

9.5 A number of States have raised objections against the investment pattern laid down for investments out of the CRF. The Finance Ministry has laid down that the accretions to the Fund should be invested in the following manner :

a) 15 per cent in Govt of India securities.

b) 25 per cent in 182 days Treasury bills.

c) 10 per cent in State Govt. securities.

d) 10 per cent in Public Sector Bonds/units.

e) 25 per cent to be maintained as deposits with Public Sector Banks (PSBs)

f) 15 per cent to be maintained as deposits with State Cooperative Banks (SCB)

9.6 Punjab is one of the few States which has actually created a separate fund and it found that the purchase of securities/bonds was a time-consuming process which tended to negate the objective laid down in the original scheme. Rajasthan has stated that investments out of the CRF should not be held on a long-term basis and that too in a basket of securities the sale and purchase of which has to be effected in the open market. Haryana has pleaded that the entire amount available should be deposited in a fixed deposit/term deposit. Assam has suggested that the procedure for investment of funds may be made simpler with greater freedom for investment in profitable avenues.

9.7 As regards calamities of rare severity, Gujarat has stated that these should be objectively defined in terms of the number of villages/people affected, quantum and extent of relief and similar other factors. Andhra Pradesh has cited the case of the disastrous cyclone which occured on 9th May, 1990 and resulted in unprecedented loss of life and property for which no additional assistance was given; it has suggested that standard criteria should be evolved for determining 'rare severity'. Tamil Nadu has stated that though it suffered an unprecedented calamity in 1992, no special help was forthcoming and as such the recommendations of the Ninth Finance Commission cannot be said to have provided a durable arrangement for such national disasters of unprecedented severity.

42

9.8 The Ministry of Finance, on the other hand, has stated that the scheme recommended by the Ninth Commission is advantageous to the States as the Central contribution is now entirely in the form of grants and the States left free to manage their affairs at their own discretion. The Ministry has also opposed the suggestion of the State Governments for a change in the investment pattern of the fund, lest the balances in the fund may not be available when needed. They have argued for the continuation of the present arrangement.

9.9 We have also received the comments of the Department of Agriculture and Cooperation of the Ministry of Agriculture who have been assigned a nodal role within the Government of India for overseeing the operation of CRF. They have reported that the response of the State Governments to requests by them for information for purposes of monitoring has not been encouraging, as the States accorded very low importance to the submission of any information to the Centre in the absence of any additional monetary assistance which could flow based on these communications. They have observed that in the absence of clear guidelines being prescribed, the States have tended to charge to the CRF all types of expenditure, including some only remotely related to calamity relief, such as office expenses at the State level and construction of new flood protection works and embankments. Their specific comments regarding the role of the Government of India under the changed scenario are as follows:

> "....in a vast country like ours, any calamity with substantial adverse impact involved the involvement of the Central Government as well (but) the scope of giving expression to the concerns of the Central Government in concrete terms has been significantly reduced under the new arrangement based on Ninth Finance Commission's recommendations."
>
> They stated that the Centre had received 30 Memoranda for additional Central assistance between June 90 and May 93 regarding natural calamities that, according to the States, required to be handled at the national level.

9.10 The Department has suggested that the States CRF should be shared between the Central and the State Government in the ratio of 50:50, and the basis for fixing the amount of the fund should be the average of the actual expenditure on relief measures during the last four years of the existing state corpus, whichever is higher. The instalments of Centre's share of the CRF may be released by the Ministry of Finance on the recommendations of the Department or the submission of utilisation reports by the States. The expenditure from the CRF should be incurred on the basis of guidelines framed by the Government of India in this regard. If the funds available under the CRF are not sufficient to meet the situation in the wake of a natural calamity, additional funds should be made available by the Central Government on the basis of the recommendations of the Central teams to be deputed for this purpose and these additional requirements should be shared between the Central and the State Governments in the ratio of 3:1. The Department has also stated that the Central Government would make an annual provision of adequate funds in addition to the Centre's share of CRF for meeting these additional requirements.

9.11 There is near unanimity on the part of the States that the present arrangement should be continued, even though certain reservations were expressed by one or two States during discussions. In the light of the fact that almost all States have asked for the continuance of the existing scheme and the Ministry of Finance have also suggested that sufficient time should be given for the scheme to be operationalised, we do not consider it necessary to change the present scheme or the pattern of the Centre-State contributions to it.

9.12 There is some substance in the observation of the Department of Agriculture and Cooperation that the practice regarding charging of different types of expenditure to the CRF has not been uniform among the States. While acknowledging that there is room for inter-State variations in items of relief expenditure, depending upon local requirements, there is nevertheless a need to evolve an All-India framework. To give one instance, it would be invidious if one State gives Rs.10,000 ex-gratia payment for the loss of life, and another gives Rs. 1,00,000. Adherence to certain broad parameters may also be necessary to withstand undue local pressures. Successive Commissions have, while noting the varying capacity of different States to meet the cost of calamity relief, also stressed the need to avoid unwarranted and wasteful expenditure.

9.13 We, therefore, recommend that the Department of Agriculture and Cooperation of the Ministry of Agriculture should set up a committee of experts and representatives of State Governments to frame common guidelines in regard to the items and their rates and norms, that can be debited to the CRF. The State committees will then work out the details for their respective States. In auditing the expenditure from the CRF it should be ensured that the designated items alone are charged to the fund and the norms are observed. We are also in agreement with the Finance Ministry that a seperate fund outside the Public Account must be created so that the balances in the fund are available when needed.

9.14 Another issue raised by several States is that the quantum of the CRF should be based on an average of the actual expenditure incurred by them on natural calamities over a given number of years and not on the basis of ceilings of expenditure approved by Government of India. However, the States have claimed expenditure booked under a variety of Heads as being expenditure relating to calamity relief. In the case of other Heads it is difficult to distinguish between expenditure incurred in connection with calamity relief and other normal expenditure booked to those Heads. On the other hand, expenditure under various Minor Heads such as gratuitous relief, supply of fodder, drinking water, veterinary care, housing etc. is subsumed under the Major Head 2245 - Natural Calamities, which can therefore be justifiably taken to represent the expenditure of State Government on all relief activities. We are, therefore, of the view that the most appropriate and objective manner of assessing relief expenditure is to take into account only the expenditure booked to Major Head 2245-Natural Calamities.

9.15 We do, however, fully share the States' misgivings with regard to the factor of inflation which may not have been suitably accommodated in the present dispensation. We have taken into account the average of the aggregate of ceilings of expenditure for the years 1983-84 to 1989-90 and the amount of calamity relief fund for the years 1990-91 to 1992-93. The amount so worked out for all the States, has been adjusted for inflation upto 1994-95 and thereafter at graduated rates with the same elasticity as for other non-plan revenue expenditure up to 1999-2000. The amount thus worked out for all States for the period of our Report is Rs.6304.27 crores as at Annexure IX.1. Out of this, the Centre will be required to contribute Rs.4728.19 crores (75 per cent) and the States Rs.1576.08 crores (25 per cent). The share of the States has been included in their expenditure estimates. We accordingly recommend the continuation of the current scheme of the Calamity Relief Fund with modifications. The main features of the modified scheme will be as follows:

a) The contribution of the Centre and States to the Calamity Relief Fund shall be as at Annexure IX.2 and IX.3 respectively.

b) The CRF should be held outside the Public Account of the State in a manner to be prescribed by the Ministry of Finance as explained next. Before releasing the amount due in any year, Ministry of Finance shall ensure that the Central contributions released in earlier years have been credited to the CRF.

c) The existing scheme for the 'Constitution and Administration of the Calamity Relief Fund and Investment therefrom', issued by the Ministry of Finance, should be modified so as to provide flexibility in the choice of avenues for investment subject to ensuring security and liquidity. Holding the funds entirely in a nationalised bank should be considered by the Finance Ministry. The Ministry should circulate a modified scheme after consulting the States by 30th June, 1995.

d) The balance in this fund will be available to the State at the end of the fifth year or thereafter for being used as a resource for the next plan.

e) The State Level Committee constituted under the existing scheme shall decide on all matters connected with the financing of the relief expenditure subject to the general guidelines issued by the Union Agriculture Ministry in terms of para 9.15 (j).

f) If it is found by the State Level Committee (constituted under the existing scheme) that in a particular year, the amount required is more than the sum available in the CRF, it may draw 25 per cent of the funds due to the State in the following year from the Centre, to be adjusted against the dues of the subsequent year. The Ministry of Finance may consult the Agriculture Ministry before making such advance releases. The Central Government may, at its discretion, allow a higher percentage of advance from the State's entitlement in the next year.

g) Periodic information relating to expenditure from the CRF and relief operations may be collected by the Department of Agriculture from the State Level Committees of the CRF.

h) The present arrangement for co-ordinating relief work at the Centre in the Ministry of Agriculture may continue so that the assistance from Defence Forces, Railways as also supply of seeds, etc., which may be required in time of natural calamities could be co-ordinated.

i) A Committee of experts, and representatives of States, may be set up by the Ministry of Agriculture to draw up a list of items, the expenditure on which alone will be chargeable to the CRF. This should be done by 1st April, 1995.

j) The norms for the amounts that can be given or spent under each of the approved items be prescribed by the State Level Committees. This should be done by 30th June, 1995. The norms so fixed should be communicated to the Union Ministry of Agriculture. They should check the norms and, if they are significantly out of line, modify them.

k) The Accountants General should then be instructed to see that only expenditure on the items approved by the Ministry of Agriculture is booked to the Head 2245 - Natural Calamities. The Ministry of Agriculture may monitor whether the State is adhering to the norms prescribed by its own Committee.

9.16 Lastly, we consider how to deal with a calamity of rare severity. Between June, 1990 and May, 1993 the Central Government is reported to have received thirty memoranda from the States claiming additional Central assistance on the ground that they had experienced a calamity of rare severity. While it is no doubt true that the country has been spared the agonies of the type witnessed during the severe drought in 1986-87 and 1987-88, which affected Rajasthan and Gujarat, nevertheless, floods and drought of varying intensity and magnitude have continued to be experienced in various parts of the country almost every year. From time to time calamities of such a severity may occur in various regions that the States are not able to manage with their own CRF. At such times the Central Government must be in a position to come to the rescue of the State and organise relief on a national scale.

9.17 We have considered the issue carefully and are of the view that a calamity of rare severity would necessarily have to be adjudged on a case-to-case basis taking into account, inter alia, the intensity and magnitude of the calamity, level of relief assistance needed, the capacity of the State to tackle the problem, the alternatives and flexibility available within the plans to provide succour and relief, etc. Any definition bristles with insurmountable difficulties and is likely to be counter-productive.

9.18 Once a calamity is deemed to be of rare severity it really ought to be dealt with as a national calamity requiring assistance and support beyond what is envisaged in the CRF Scheme. It goes without saying that additional assistance from the Centre would be required. But the national dimensions of such a calamity can be brought out only if all States also come to the succour of the affected State. In actual fact this has been happening in the past when many States did extend support to the affected State both in terms of financial grants and by sending material help and teams of doctors, etc. We would like to place this urge for national solidarity in a moment of distress on a more formal basis in our scheme. We, therefore, propose that in addition to the CRFs for States, a National Fund for Calamity Relief should be created to which the Centre and the States will subscribe and which will be managed by a National Calamity Relief Committee on which both the Centre and the States would be represented. This fund will be for dealing with calamities of rare severity and will be managed at the national level by a sub-committee of the National Development Council. This committee headed by the Union Agriculture Minister could comprise the Dy. Chairman, Planning Commission, and two Union Ministers and five Chief Ministers to be nominated by the Prime Minister annually by rotation. The Department of Agriculture should provide the secretariat for this fund . The nomination of the Chief Ministers should be done in March of each year for the next financial year.

9.19 The National Fund for Calamity Relief (NFCR), will be operated by the Ministry of Agriculture, Government of India but it will be maintained outside the Public Account of the Government of India as recommended by us for CRFs of States. The Ministry of Finance will prescribe guidelines for this as we have recommended it should do in the case of the CRF. The accounts of the NFCR shall be audited annually by the Comptroller and Auditor General. The admissible items of expenditure, norms etc. for this fund should be worked out by the Committee of Experts which we have recommended above for a similar purpose in the case of CRFs.

9.20 The size of the fund would be Rs.700 crores, to be built up over the period 1995-2000, with an initial corpus of Rs.200 crores to which the Centre would contribute Rs.150 crores and the States Rs.50 crores in the proportion of 75:25. In addition, for each of the five years from 1995-96 to 1999-2000 the contributions of the Centre and the States would be Rs.75 crores and Rs.25 crores respectively. The contribution by both the Centre and the States would be made annually in the beginning of the financial year. Contribution of States inter-se would be in the same proportion as their estimated total tax receipts after devolution. The share of each of the States, as indicated at Annexure IX.4, has been included in the reassessment of expenditure of the States.

9.21 We hope that with the setting up of the National Fund for Calamity Relief it would now be possible to tackle calamities of rare severity more effectively . What is more, we hope that the system recommended by us would also help create a sense of national solidarity in a common endeavour which would then abide beyond the period of distress.

Appendix V: Hedging Catastrophe Risk Of Residential Mortgage Loan Portfolios

Overview: Mortgage lenders without any risk management program in place on their portfolio of loans are affected by losses arising from catastrophic events. We first demonstrate the potentially serious effects of a natural catastrophe on an unhedged mortgage portfolio, including lower credit rating, loss of equity, and insolvency of the lender. We next discuss ways in which lenders can minimize catastrophic losses by preparing for these events.

Natural Disasters and Homeowner Insurance: Natural disasters can have devastating consequences including loss of life, property, jobs, and businesses. The cost of managing these events puts fiscal strains on government budgets, often leading to (or increasing) a budget deficit, particularly in smaller, developing countries. Homeowner property insurance policies do not generally include natural catastrophe coverage; additional coverage needs to be purchased for catastrophic events such as earthquake, flood, and cyclone. We use an example to reveal the potential scale of natural catastrophe related losses to a mortgage lender, and demonstrate that lack of catastrophe insurance can lead to homeowners' loss of equity and have severe consequences on a mortgage lender's portfolio.

Consider a scenario with one mortgage lender, ABC Bank ("ABC"), which owns a portfolio of US$100 million residential mortgage loans in a seismically active region. The makeup of this portfolio consisted of loans originating in the last 25 years. ABC did not have any risk management program in place and assumed full portfolio risk, including that of natural disasters. Because ABC did not require borrowers to take out earthquake insurance, borrowers did not purchase any. In addition, a disproportionate number of properties (70%) in ABC's portfolio were located in the high risk areas of the region. ABC's underwriting policy allowed for a maximum three month delinquency period for the lifetime of the loan, after which ABC could proceed with foreclosure. No major catastrophes had emerged in the region in the last 25 years and ABC's portfolio had not suffered any losses.

A major earthquake with high intensity hits the region causing extensive property damage. 2,000 borrowers who incurred losses less than 5% of unpaid principal balance (UPB), stayed current on their mortgage. However, a number of borrowers out of the remaining 3,000 became delinquent in their mortgage payments; though after three months a few borrowers resumed payments, the rest defaulted on their loans. During the three month delinquency period ABC lost both principal payment and interest income on a substantial number of loans.

ABC portfolio pre-event average Loan-to-Value ratio[96] ("LTV") was 80%, but the extensive damage to properties made the post-event LTV jump to 190%. The substantial number of defaults on ABC's and other lenders' portfolios in the region increased the supply of properties in the market. As lenders tried to liquidate the repossessed properties, buyers became scarce and the real estate market dropped by 30%.

ABC tried to raise funds to keep its business solvent, but there were no willing lenders in the market since ABC's credit rating had deteriorated and dropped significantly following defaults on its portfolio. Because of its poor credit rating and lack of sufficient funds, ABC could not

[96] Ratio of unpaid principal balance to property value.

restore the properties or wait for the market to stabilize. ABC had to sell the properties at rock bottom prices to recover some of the losses.

As mentioned earlier, ABC portfolio had a high concentration of properties in the high risk areas of the region. The heavy concentration of portfolio in one region made the loans riskier than a geographically diversified portfolio, which would have spread the risk. The portfolio was a mixture of loans with different maturities, anywhere from one month to 25 years. Table A 5.1 compares and contrasts the impact of high, moderate and low risk concentrations on a portfolio of mortgage loans. From Table A 5.1, one can observe that although an average LTV of 80% is reasonable for a portfolio of mortgage loans, ABC would need a risk management program to sustain its business after a natural catastrophe. ABC should have determined its risk tolerance and established a policy where no more than a certain percentage of loans were concentrated in one region.

Table A 5.1: Assumptions and Calculations for ABC Bank

If Post Event LTV ≥120%, Borrower Defaults	
Land to property Ratio	**60.0%**
Portfolio	US$ 100,000,000
Number of Loans	5,000
Average Property Value	$25,000
Average UPB	$20,000
Land Value	$15,000
LTV	**80.0%**
Number of Properties with Damage ≤5%	2,000
UPB of Properties with Damage > 5%	$60,000,000
Properties in High Risk Area	70.0%
Properties in Moderate Risk Area	20.0%
Properties in Low Risk Area	10.0%
Post Event Property Depreciation	30.0%
Post Event Property Value	$10,500
Post Event LTV	**190.5%**
High Risk	
PML Concentration Factor**	10.5%
Post Event Default	30.0%
Default Due to High Risk	21.0%
Gross Loss	$12,600,000
Foreclosure Revenue	$6,615,000
Net Loss	$5,985,000
Moderate Risk	
PML Concentration Factor**	7.0%
Post Event Default	10.0%
Default Due to Moderate Risk	2.0%
Gross Loss	$1,200,000
Foreclosure Revenue	$630,000
Net Loss	$570,000
Low Risk	
PML Concentration Factor**	3.5%
Post Event Default	1.0%
Default Due to Low Risk	0.1%
Gross Loss	$60,000
Foreclosure Revenue	$31,500
Net Loss	$28,500
Total Net Loss	**$6,583,500**
For simplicity, we ignored lost interest income, cost of carry and foreclosure expenses	
* If damage is ≤5%, borrower does not default	
** Factors are based on estimated Gujarat PMLs for high, moderate and low risk concentration	

Solvency Issues of ABC: ABC incurred US$13.9 million of gross losses, and was able to recover US$7.3 million from land value of foreclosed properties. ABC was unable to maintain its 8% or US$8 million regulatory capital requirement based on the Basel Capital Accord. ABC was forced to raise funds to cover a shortfall of US$6.6 million in losses, which proved to be difficult due to its poor credit rating as a consequence of defaults. Despite earnings of US$3 million, given the regulatory capital requirement of US$8 million and net losses of US$6.6 million, ABC became insolvent.

Table A 5.2 illustrates that even with an average pre-event LTV of 50.5%, due to the post-event scarcity of buyers and decrease in land value, average post-event LTV would have increased to 120%. ABC would have benefited from borrower paid earthquake insurance coverage and minimized losses.

Table A 5.2: Pre-event vs. Post-event LTV

If Post Event LTV ≥ 120%, Borrower Defaults	
Average Land to property Ratio	**60%**
Portfolio	US$ 100,000,000
Number of Loans	5,000
Average Property Value	$39,604
Average UPB	$20,000
Average Land Value	$23,762
Average LTV	**50.5%**
Average % Property Depreciation	30%
Average Post Event Property Value	$16,634
Average Post Event LTV	**120%**

Preparation for Catastrophic Risk and Loss Minimization: We now recommend methods to help lenders manage portfolio risk and minimize exposure to low frequency–high severity events. To ensure that layers of risk above tolerance are transferred, to the extent available, lenders should either require borrower paid earthquake insurance coverage in their underwriting practice, or transfer this risk via insurance or capital markets. Lenders should conduct studies to have a better understanding of the inherent risk in their portfolio. Freddie Mac, an agency investor in the secondary market, requires condo owners in California to purchase earthquake insurance based on the risk level of the area and zip codes. The risk level is calculated by applying the Earthquake Insurance Requirement Matrix prepared by Risk Management Solution, a risk modeling firm in California. Lenders/ investors who do not have this requirement in California may end up with riskier condominium loans on their portfolio.

Risk Analysis: Lenders need to understand and analyze risk of their portfolio. The key to any analysis is accurate and up to date information on borrowers and on properties (such as type, age, proximity to default lines, and current market value). LTV determines the value of borrower equity, the difference between the market value of property and the unpaid balance (UPB). The market value of a property updates LTV, which is the main driver in the borrowers' decision whether to default. The higher the LTV, the likelier the borrower default. However, in some cases, borrowers with high LTV may not default due to psychological attachment to their properties and separation from home or community. Estimated post-event LTV enables lenders to make a sound assessment of potential losses. Information on borrowers allows lenders to conduct annual forecasting and sensitivity analysis using simulation models.[97]

Modeling Risk and Methodology: After a catastrophic event the following chain of events lead to lender losses:

Catastrophic Event → Property Damage → Post Event Borrower Equity → Borrower Default → Foreclosure Proceeds → Lender Loss

To assess risk of a portfolio, simulation models subject it to stochastic analysis by randomly applying two million events, such as earthquake, to each property with different severity and frequency. The model calculates probability distribution for each event to estimate property damage and translates it into dollar losses. Post-event borrower equity, the measure of equity left in the property, is derived using post-event value of property and UPB. The borrower may decide whether or not to default based on his equity. To assess the likelihood of borrower default, historical data is used to develop a default algorithm using post-event LTV.[98] [99] These default probabilities are then applied at the loan level to estimate losses, given the severity of damage to property and the resulting post-event LTV. Proceeds from foreclosure are estimated and net loss to the lender is calculated.

The output of the analysis serves as a guideline for lenders in measuring annual expected losses, probability of loss exceedance and PMLs.[100] [101] These measures enable lenders to take corrective actions and select a PML consistent with their risk tolerance and objectives.

Lenders account for loss of income such as interest income and administrative cost due to foreclosures. Contributing factors such as the state of economy and interest rate movements are taken into account, since these are additional factors that influence a borrower's decision whether to default. Home price and interest rate sensitivity analyses prepare lenders for any potential downturn in the housing market and allow them to adjust the market value of properties accordingly for any depreciation or appreciation. For portfolios concentrated in one region, lenders should keep abreast of economic conditions at both the micro and macroeconomic levels.

Lenders can either restore and sell the property, or sell the property at its post-event condition. After a catastrophic event, in a depressed market and with a scarcity of buyers, lenders may have to write off a significant portion of their portfolio due to property depreciation. For defaults following a major catastrophe, cost/benefit analysis should be performed to examine the viability of restoring properties; in some circumstances a lender may not be able to afford restoration costs and has to recover losses based on land value alone. In situations where borrowers cannot

[97] The lender can either develop the model internally or hire a modeling firm specializing in catastrophe analysis to conduct the task.

[98] If such data is not available at the regional level, the lender can use data from other regions with same characteristics.

[99] E.g., assumption for default algorithm of ABC: if LTV $\geq$120%, borrower defaults.

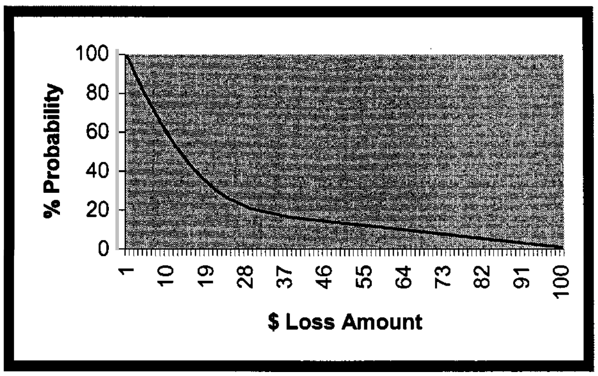
[100] Annual expected losses = UPB x Σ (Frequency x Severity) / Σ Frequency.

[101] Probability of losses exceeding certain loss thresholds.

make payments for a short period of time, the lender may consider other alternatives to prevent default, such as a workout plan to allow borrowers to delay payments or provide additional loan to the borrower for restoring the property.
It should be noted that a mortgage portfolio is not automatically affected by damages/losses to properties after a catastrophic event. For a mortgagee to suffer losses, the default should follow damage to property, and the mortgagor should be unable to make future payments. Having information on other assets and credit worthiness of the borrower will enable the lender to make a better assessment of the borrower's potential likelihood of default. Mortgage default is usually the last option for the borrower after exhausting all other assets.

The risk curve in figure 5.1 shows probability of exceeding specific losses. Lenders use probability of loss exceedance to decide on the layers of risk to be transferred.

Figure A 5.1: Risk Curve



Risk Management Alternatives: Risk modeling is a fundamental and effective tool to use when deciding on mechanisms to manage risk. Lenders should manage expected losses and finance or transfer risk above their tolerance, in accordance with their objectives. Risk tolerance of a business usually depends on a portion of earnings that shareholders are willing to lose.

If losses are covered under borrower paid catastrophe coverage, the lender should consider indirect counter party risk, that is, the credit worthiness of the insurer. Where borrower paid coverage is not available, lenders may decide on an option that transfers their catastrophe risk and best hedges their portfolio. Below are some alternatives:

Risk transfer: Lenders can purchase reinsurance or an option based insurance allowing them to transfer losses to a third party.

Risk Financing: One alternatives is a contingent finance arrangement, which is essentially a put option allowing the insured to issue debt at a pre-negotiated price/rate. This arrangement allows lender to raise funds to cover losses. Another alternative is finite risk, an arrangement with a third party to smooth losses over a period of time

Risk Sharing Arrangements: In some developed mortgage markets, mortgage lenders share risk of default with mortgage insurers. Default insurance or private mortgage insurance allows lenders to share risk of default regardless of the cause of default.

Conclusion: We have observed that the portfolio of mortgages is not immune to natural disasters. As illustrated by our example, a profitable mortgage lending business can become insolvent due to a natural disaster.
France, Japan, New Zealand, United Kingdom and the states of Hawaii, Florida and California have implemented programs to deal with catastrophic risk. Some countries such as the United States have the resources to provide government assistance for natural disasters. However, this may not be feasible for developing countries with limited resources. It may be prudent for countries with limited resources to require mandatory home buyer and/or catastrophic insurance to prevent a significant fiscal burden on the government and to keep their mortgage markets solvent. This policy has already been adopted in some Latin American countries. Borrowers, lenders and governments can all benefit from an insurance plan that reduces the risk of default for all parties involved.

Bibliography

Anand. Dr. H., Orissa Mission Report & Composite Plan of Action, United Nations Disaster Management Team / UN India, 1999. (http://www.un.org.in/dmt/orissa/Reports.htm).

Anderson, M. B., "Vulnerability to Disaster and Sustainable Development: A General Framework for Assessing Vulnerability." in M. Munasinghe and C. Clarke, eds., Disaster Prevention for Sustainable Development: Economic and Policy Issues. IBRD / World Bank, 1995. pp. 41-59.

Andersen, T., et al., "Disaster Insurance and Risk Management in South Asia: Contemporary Country Risk Management Approaches." World Bank Technical Paper, 2002.

Anderson, T. and Kalavakonda, V., "The Economic Consequences of Catastrophe Events: An exploratory study of exposed developing countries." World Bank, forthcoming.

Arrow, K. J. and Lind, R. C., "Uncertainty and Evaluation of Public Investment Decision." The American Economic Review, 1970, 60: 364-378.

ASCE, Standard 7 "Minimum Design of Loads for Buildings and Other Structures." 1998.

Benson, C., "The Economic Impacts of Natural Disasters in Fiji." ODI Working Paper 97. Overseas Development Institute, 1997.

Benson, C., "The Economic Impacts of Natural Disasters in Philippines." ODI Working Paper 99, Overseas Development Institute, 1997.

Benson, C., "The Economic Impacts of Natural Disasters in Vietnam." ODI Working Paper 98, Overseas Development Institute, 1997.

Bertrand, A. J.M., The Political Economy of Large Natural Disasters. Clarenden Press, 1994.

Bhatt, Natural Disasters as National Shocks to Poor and Development. World Bank, 1999.

Brown. W, Green, C., and Lindquist, G. "A Cautionary Note for Microfinance Institutions and Donors Considering Developing MicroInsurance Products." Microenterprise Best Practices Project, USAID, 2000.

Browne, M. and Hoyt, R., "The Demand for Flood Insurance: Empirical Evidence." Journal of Risk and Uncertainty, 20:3;291-306,2000.

Business Line, April 23, 2001 (Financial Daily owned by The Hindu Group of publications. Article taken from online document).

Cook, N.J., The Designer's Guide to Wind Loading of Building Structures. Butterworth-Heinemann, 1986.

Cutler, D. M., and Zeckhauser, R., "The Anatomy of Health Insurance." NBER Working Papers 7176, National Bureau of Economic Research, 1999.

Cutler, D. M. and Zeckhauser, R., "Reinsurance for Catastrophes and Cataclysms." in Kenneth A. Froot, ed., The Financing of Catastrophe Risk (Chicago: University of Chicago Press, 1999), pp. 233-269.

Dheri, S. K., "Managing Disasters in Urban Areas." in Sahni, et al., Disaster Mitigation, Prentice-Hall, 2001.

Doherty, N., Integrated Risk Management. McGraw Hill, 2000.

Dunleavy, H. Jeanne, "Capital Considerations of Insurers with Catastrophe Exposure." 1998 (http://www.casact.org/coneduc/specsem/98catast/dunleavey.ppt).

FEMA's Standardized Earthquake Loss Estimation Methodology.

Frank, W.M., "The Structure and Energetics of the Tropical Cyclone Part I: Storm Structure." Monthly Weather Review, vol.105, pp. 1119-1135, 1977.

Freeman, P. and Martin, L., National Systems for Comprehensive Disaster Management: Financing Reconstruction. IDB, May 2002.

Froot, K., The Financing of Catastrophe Risk. NBER, 1999, p.7.

Froot, Kenneth A., "The Market for Catastrophe Risk: A Clinical Examination." Working Paper No. 7286 (Cambridge, Mass.: National Bureau of Economic Research, February 2001).

General Insurance Corporation of India (GIC), 29th Annual Report, 2000-2001.

Giles, T. and Biggar, S., Risk Allocation, Burden on the Central Budget and Fiscal Benefits. Charles River Associates, 2000 and 2001.

Gibert R., "Doing More for Those Made Homeless by Natural Disasters." Disaster Risk Management Working Paper Series No. 1, World Bank, 2001.

Grace. M., Kleindorfer, P., and Klein, R., "The Demand for Homeowners Insurance with Bundled Catastrophe Coverage." Paper Presented at National Bureau Of Economic Research, Insurance Project Workshop, January 28, 2002.

GSI, Seismotectonic Atlas of India and Its Environs, Calcutta, 2000.

High Powered Committee on Disaster Management, "HPC Report at a Glance: Building a Culture of Prevention." Department of Agriculture and Cooperation, Government of India, 2001.

Hirshleifer, J., "Investment Decisions Under Uncertainty: Applications of the State-Preference Approach." Quarterly Journal of Economics, Nov. 1965.

IFRC, World Disaster Report, 2001.

Institute of Administration Natural Disasters Conference, Delhi, February 2002.

Insurance Regulatory and Development Authority (IRDA), First Annual Report, 2000-2001.

Insurance Regulatory and Development Authority (IRDA), Second Annual Report, 2001-2002.

ISET, "Catalogue of Earthquakes in India & Neighbourhood." Roorkee, 1983.

Jaffee, D. and Russell, T., "Catastrophe Insurance When Capital is Limited: A Comparison of Public and Private Approaches." Paper prepared for Pacific Rim Insurance Conference, September 1997.

Jayanthi, N. and Sarma, A.K.S., "Rainfall Associated with Cyclonic Disturbances from Indian Seas during Pre and Post Monsoon Seasons." Pre-published scientific report no. 87/2, RMC, Madras, 1987.

Kleindorfer, P., and Kunreuther, H., "Managing Catastrophe Risk." in Regulation, Volume 23, No.4: 26-31.

Lahiri et al., "Economic Consequences of the Gujarat Earthquake." Gujarat Earthquake Assessment Mission, Asian Development Bank, 2001.

Lavall, A., "The Impact of Disasters on Development Gains: Clarity or Controversy." IDMDR Forum, July 1999.

Lester, R. and Galabova, T., "Is Insurance a Luxury?" *The Actuary*, Institute of Actuaries, 2002.

Litan, R., "The Impacts of Natural Disasters: A Framework for Loss Estimation." Committee on Assessing the Costs of Natural Disasters, National Research Council, National Academy Press, 1999.

Major, J. A., "The Uncertain Nature of Catastrophe Modeling." in *Natural Disaster Management*, Tudor Rose, London, UK, 1999.

Mandal, G.S., "Various Aspects of Tropical Cyclones in the North Indian Ocean." Ph.D. thesis, Jadavpur University, Calcutta, 1990.

McCarten, W., "The Challenge of Fiscal Discipline in The Indian States." in Fiscal Decentralization and the Challenge of Hard Budget Constraints, Rodden, J. et al., MIT Press, 2003.

Mechler, R., "Natural Disaster Risk Management and Financing Disaster Losses in Developing Countries." PhD. thesis, University of Karlsruhe, 2002.

Mishra, K., "Monogram of Cat-risk insurance in India retrospect and prospect." National Insurance Academy, 2002.

Moore, James F., "Tail Estimation and Catastrophe Security Pricing: Can We Tell What Target We Hit If We Are Shooting in the Dark?" Working Paper No. 99-14 (Philadelphia: Wharton Financial Institutions Center, 1999), available at http://fic.wharton.upenn.edu/fic/.

Outreville, J., "The Retention Capacity of Insurance Markets in Developing Countries." Handbook of Insurance, Kluwer, 2000, p.749.

Peacock et al., Hurricane Andrew, Ethnicity, Gender and the Sociology of Disasters. Routledge, 1997.

Proposal on Federal Reinsurance for Disasters, Congressional Budget Office, September 2002.

Rao, C.H.G., Real Estate Practices, 1997.

Report of the Expert Group on Natural Disaster Prevention, Preparedness & Mitigation having bearing on Housing and Related Infrastructure – Part I, 1998.

UNCTAD, "A Ten Country Analysis of Catastrophe Exposure, Insurance Sector and Country Financial Capacity To Bear Risk." UNCTAD Secretariat background document, UNCTAD/SDD/INS/8, October 1995.

U.S. Army Corps of Engineers, Manual No. 1110-2-1420, "Flood-Runoff Analysis Proponent." 1997.

Vate, M. and Dror, D., "To Insure or Not to Insure? Reflections on the Limits of Insurability." in Social Re-Insurance, ILO and World Bank, 2003.

GLOSSARY

Acquisition Costs - All expenses directly related to acquiring insurance or reinsurance accounts, i.e., commissions paid to agents, brokerage fees paid to brokers, and expenses associated with marketing, underwriting, contract insurance and premium collection.

Aggregate Excess of Loss Reinsurance - A form of excess of loss reinsurance which indemnifies the ceding company against the amount by which all of the ceding company's losses incurred during a specific period (usually 12 months) exceed either (1) a predetermined dollar amount or (2) a percentage of the company's subject premiums (loss ratio) for the specific period. This type of contract is also commonly referred to as "stop loss" reinsurance or "excess of loss ratio" reinsurance.

Aggregate exceedance probability (AEP) - A measure of the probability that one or more occurrences will combine in a year to exceed the threshold. See also "occurrence exceedance probability."

Annual rate of occurrence - Average number of occurrences per year. This statistic is reported in RiskLink® EP analyses. Not to be confused with the term "probability," which refers to the probability of at least one event occurring in a year.

Attenuation - The reduction in ground motion with distance from an earthquake. The ground motions resulting from an earthquake decay as they travel away from the fault. An attenuation equation is used to estimate this decay based on the magnitude of the earthquake as well as the distance and depth to the source.

Block - An administrative sub-division of a district, which in turn is a sub-division of a state. A block is larger than a postcode.

Boundary files - Geographical mapping files that represent administrative or other regions for purposes of creating maps to visualize risk information.

Building inventory database - Database representing the distribution of types of structures within the built environment, for a given region such as a state or a country.

Capacity - The largest amount of insurance or reinsurance available from a company or the market in general. Also used to refer to the maximum amount of business (premium volume) which a company or the total market could write based on financial strength.

Catastrophe Reinsurance - A form of excess of loss reinsurance which, subject to a specific limit, indemnifies the ceding company in excess of a specified retention with respect to an accumulation of losses resulting from a catastrophic event or series of events arising from one occurrence. Catastrophe contracts can also be written on an aggregate basis under which protection is afforded for losses over a certain amount for each loss in excess of an aggregate amount for all losses in all catastrophes occurring during a period of time (usually one year).

Cede - To transfer to a reinsurer all or part of the insurance or reinsurance risk written by a ceding company.

Ceding Commission - In calculating a reinsurance premium, an amount allowed by the reinsurer for part or all of a ceding company's acquisition and other overhead costs, including premium taxes. It may also include a profit factor. See Overriding Commission.

Ceding Company (Also Cedent, Reinsured, Reassured) - The insurer which cedes all or part of the insurance or reinsurance risk it has written to another insurer/reinsurer.

Central pressure - The lowest instantaneous atmospheric pressure at the center of a storm or depression.

Central pressure difference - The difference between the atmospheric pressure (central pressure) at the center or eye of the storm and the pressure at the periphery of the storm.

Centroid - A point latitude and longitude which is meant to represent the center of a defined geographical area.

Cession - The amount of insurance risk transferred to the reinsurer by the ceding company.

Commission - In reinsurance, the primary insurance company usually pays the reinsurer its proportion of the gross premium it receives on a risk. The reinsurer then allows the company a ceding or direct commission allowance on such gross premium received that is large enough to reimburse the company for the commission paid to its agents, plus taxes and its overhead. The amount of such allowance frequently determines profit or loss to the reinsurer.

Cyclone - Area of low-atmosphere pressure with winds blowing around it, counterclockwise in the Northern Hemisphere, clockwise in the Southern Hemisphere. See "tropical cyclone" and "extra-tropical cyclone."

Damage - Any economic loss or destruction caused by earthquakes, windstorms, and other perils.

Damage ratio - The repair cost of a location represented as a percentage of the value at that location.

Depth of earthquake - The distance from the hypocenter of an earthquake to the surface of the earth. Also called the hypocentral depth or focal depth.

Direct loss – Stock losses including destruction of infrastructure, productive capital and housing.

Duration - A qualitative or quantitative description of the length of time during which ground motion at a site shows certain characteristics, such as perceptibility or large amplitudes.

Earned Premium - (1) That part of the premium applicable to the expired part of the policy period, including the short-rate premium on cancellation, the entire premium on the amount of loss paid under some contracts, and the entire premium on the contract on the expiration of the policy. (2) That portion of the reinsurance premium calculated on a monthly, quarterly or annual basis which is to be retained by the reinsurer should their cession be canceled. (3) When a premium is paid in advance for a certain time, the company is said to "earn" the premium as the time advances. For example, a policy written for three years and paid for in advance would be one-third "earned" at the end of the first year.

Earthquake - A sudden or abrupt movement along a fault or other pre-existing zone of weakness in response to accumulated stresses.

Earthquake magnitude - A scale defined by scientists to quantify the "dimension" of an earthquake. There are a number of different magnitude scales including *local magnitude* (M_L), *surface wave magnitude* (M_S), and *body-wave magnitude* (m_b). Each scale measures how fast the ground moves at some distance from the earthquake for a specific frequency band. Because they do not look at the entire frequency range of an event, the different magnitude scales will produce similar, but possibly different magnitudes. This difference becomes more pronounced for large events (>6.5). For this reason, it is very important to note which magnitude scale has been quoted for a given earthquake. Seismologists have recently developed a new scale, moment magnitude (M_w), which is calculated from the total energy released by the earthquake. The media often reports magnitudes using the "open-ended" Richter scale, developed for a specific type of seismograph that is no longer in use. Richter magnitudes usually refer to local magnitudes, but should be viewed with caution unless additional information is provided.

Economic loss - Total losses from a catastrophe that include direct and indirect losses, as well as insured losses and those losses paid by all other sources (such as property owners and the public sector).

Elements at risk - Population, buildings, and civil engineering works, economic activities, public services, utilities and infrastructure, etc., that are at risk in a given area.

Epicenter - The surface of the earth directly above the hypocenter of an earthquake, where the hypocenter (or focus) is the point at which the fracture of the earth's crust begins, thus triggering an earthquake. Represented by latitude and longitude coordinates for risk modeling purposes.

Equalization reserve - Long-term reserve set aside by the insurer or reinsurer in order to equalize operating results from certain catastrophe risks.

Event loss table (ELT) - In its basic form an event loss table contains columns of event ID, event loss and event rate of occurrence. In its expanded form columns for associated uncertainties of loss and rate are also provided.

Event set - The set of discrete events used in probabilistic risk modeling to simulate a range of possible outcomes.

Exceedance probability (EP) - Also known as "exceeding probability" or "EP," it is the probability of exceeding specified loss threshholds. In risk analysis, this probability relationship is commonly represented as a curve (the EP curve) that defines the probability of various levels of potential loss for a defined structure or portfolio of assets at risk of loss from natural hazards.

Exceeding probability - See "exceedance probability."

Excess of Loss Reinsurance - A form of reinsurance which, subject to a specified limit, indemnifies the ceding company against the amount of loss in excess of a specified retention. It includes various types of reinsurance, such as catastrophe reinsurance, per risk reinsurance, per occurrence reinsurance and aggregate excess of loss reinsurance. See also Non-Proportional Reinsurance.

Exposure - The total value or replacement cost of assets (such as structures) that is at risk from a loss-causing event such as a catastrophe.

Exposure data - Information describing the exposures, used as an input for risk modeling. For insured property exposure, this information includes: geographic location (e.g., state, county, postal code), physical characteristics (e.g., occupancy type, construction class, year built, height of structure, building/contents/time element contributions), replacement cost value (building/contents/time element), and financial structure (limits, deductibles, % insured, insurance-to-value).

Fault - Break in the earth's crust along which movement occurs or has occurred. Sudden movement along a fault produces earthquakes. Slow movement produces seismic creep.

Filling - Weakening of a storm such as a tropical cyclone as it moves inland.

Flash flood - Flooding with a rapid water rise.

Flat Rate - (1) A fixed rate not subject to any subsequent adjustment; (2) A reinsurance premium rate applicable to the entire premium income derived by the ceding company from the business ceded to the reinsurer, as distinguished from a rate applicable to excess limits.

Forward velocity - The speed at which the center of a low-pressure system moves forward. Also known as translational velocity (Vt). This is not the rotational velocity of the winds around the center of the low-pressure system.

Gate - For modeling purposes, short sections along a hurricane-prone coastline or along some other geographic feature through which stochastic storms such as hurricanes can be simulated. Generally these are 50 mile sections of coastline.

Geocoding - The process of associating an address (such as a street or postal address) with an estimate of the latitude and longitude that represents the location on the ground.

Gradient wind - A calculated wind speed that represents the velocity of air movement at altitude in response to the dynamic pressure gradient that is associated with an extra-tropical cyclone.

Ground Up (From the) - A phrase referring to reinsurance losses subject to the contract under consideration before the application of the retention, but after reduction because of any other reinsurance which inures to the benefit of the coverage being considered. Also sometimes used to describe losses before reduction for inuring reinsurance.

Hazard - A condition that may create or increase the chance of loss from a peril.

High resolution - Adjective referring to data that is at a highly detailed level of geographic definition.

Historical storm - Any storm such as a hurricane, typhoon, or extra tropical cyclone, that has already occurred.

Hypocenter - The point on the fault where rupture is initiated at the start of an earthquake, also known as the focus.

Indirect loss - Flow losses including loss of government revenues, reduction in GDP growth and opportunity costs.

Insurance - System under which individuals, businesses, and other organizations or entities, in exchange for payment of a sum of money (a premium), are guaranteed compensation for losses resulting from certain causes under specified conditions.

Insured loss - The portion of total economic loss from a catastrophe that is paid by insurance policies, including payments made by insurance carriers based on recoveries from reinsurance contracts or other financial guarantees. This excludes deductibles paid by the policy holder as well as losses that are not covered by insurance (such as losses above insurance limits or losses for perils that are not insured).

Intensity - A measure of the physical strength of a damage causing event such as an earthquake or windstorm. Common scales for intensity include the MMI scale for earthquakes, the Saffir-Simpson scale for tropical cyclones, the F-intensity for tornadoes, and the H-intensity for hail.

Landfall location - The point at which the eye of a tropical cyclone (hurricane, typhoon, cyclone) first crosses over land. Expressed in terms of latitude and longitude coordinates.

Landslide - Massive down slope movement of soil and rock materials, often generated by earthquakes.

Layer - A horizontal segment of the liability insured, e.g., the second $100,000 of a $500,000 liability is the first layer if the *cedant* retains $100,000, but a higher layer if it retains a lesser amount.

Lifeline - The utilities, highway systems, and other systems that are needed to support a population.

Line of business (LOB) - A name or code used to specify a particular policy form. Examples in the U.S. include : Residential Lines - Single-Family Dwelling, Renters, Condos, and Mobile Home; Commercial Lines - General Industrial, General Commercial, and Multi-Family Commercial.

Liquefaction - The temporary transformation of a solid soil into a semi-liquid state when vibrated. Liquefaction is most likely to occur in young, water- saturated sediments, particularly those with large amounts of sand.

Local soil conditions - The potential for ground motion amplification by the geologic materials underlying a site. RMS classifies soils along a spectrum ranging from hard rock (least amplification) to soft soils such as bay mud or artificial landfill (most amplification).

Location - A place with a single building or structure. Where several buildings are next to each other, each would be considered a separate location. Also see site.

Loss - The part of the damage suffered by each party. For the insured, it is the deductible plus any loss over the limit. For the insurer, it is generally the damage amount in excess of the deductible, not exceeding the limit. For a reinsurer, it would be the reinsurer's portion of the insurer's loss.

Loss Loading or "Multiplier" (Also Loss Conversion Factor) - A factor is applied to the anticipated losses (or loss cost) for an excess of loss reinsurance agreement in order to develop the reinsurance premium (or rate.) This factor provides for the reinsurer's loss adjustment expense, overhead expense, and profit margin.

Magnitude - The measurement of an earthquake's energy as determined by measurements from seismographic records. There are a number of different magnitude scales that are used depending on how the seismic energy was measured, which usually yield values in the same range. See "earthquake magnitude".

Maximum credible earthquake - Maximum credible earthquake is defined as the most severe earthquake that is believed to be possible along a particular earthquake source or fault segment based on geological and seismographic evidence.

Mean damage ratio (MDR) - The amount of damage, expressed as a percentage of the value, that a typical building of a specific class will incur for a given shaking intensity or wind peak gust.

Modified Mercalli Intensity (MMI) - Modified Mercalli Intensity is a subjective scale used to describe the observed local shaking intensity and related effects of an earthquake. This scale ranges from I (barely felt) to XII (total destruction), with slight damage beginning at VI. In general, the MMI will decrease with distance from the fault, except in regions with poor soils. Intensity is different from magnitude, which is a measure of earthquake "dimension" rather than effects.

Modifier - Any factor used to adjust the basic classification vulnerability attributes of a specific risk.

Natural hazard - Any natural phenomenon that poses a hazard to society, the economy, or financial assets. Examples include earthquakes, fires, windstorms, floods, extreme temperature, and other atmospheric phenomena.

Obligatory Treaty - A reinsurance contract under which business must be ceded in accordance with contract terms and must be accepted by the reinsurer.

Occupancy - Categories of usage for a structure. Used as an input factor in estimating vulnerability to loss.

Occurrence exceedance probability (OEP) - A measure of the probability that a single occurrence will exceed a certain threshold. See also "aggregate exceedance probability".

One-minute wind speed - The maximum averaged one-minute wind speed at 10 meters (30 feet) above the ground. Used as one of the criteria to rate storms on the Saffir-Simpson intensity scale.

Orientation - Orientation indicates the bearing of a fault relative to due north. It is expressed as a value between -90° (due west) and 90° (due east) relative to due North (0°).

Peak ground acceleration (PGA) - The maximum value of ground motion acceleration as displayed on an accelerogram. A measurement of the maximum pulse of ground shaking at a location.

Peak gust - The maximum 3-second sustained wind gust at 10 meters (30 feet) above the ground. Since the peak gust is sustained for a relatively brief period of time, it typically is substantially higher than a 1-minute wind speed.

Peril - The loss producing agent, such as a storm (hurricane, tornado, other windstorm), earthquake, or flood.

Pool (Also Association, Syndicate) - An organization of insurers or reinsurers through which pool members underwrite particular types of risks with premiums, losses, and expenses shared in agreed amounts.

Primary - In reinsurance this term is applied to the nouns: insurer, insured, policy and insurance and means respectively: (1) the insurance company which initially originates the business, i.e., the ceding company; (2) the policyholder insured by the primary insurer; (3) the initial policy issued by the primary insurer to the primary insured; (4) the insurance covered under the primary policy issued by the primary insurer to the primary insured (sometimes called "underlying insurance").

Probabilistic model - A model that assesses the impact of a hazard and assigns probabilities to a whole range of possible outcomes.

Probability - See annual rate of occurrence.

Probability of exceedence - The probability that the actual loss level will exceed a particular threshhold.

Probability of non-exceedance - The probability that the actual loss level will not exceed a particular threshhold.

Probable maximum loss (PML) - A general concept applied in the insurance industry for defining high loss scenarios that should be considered when underwriting insurance risk. The exact probability or return period associated with a PML can vary based on the company's policies and objectives.

Radius to maximum wind (Rmax) - A distance measured normal to the track of a storm to the location where the winds experienced throughout the storm were highest.

Rate - The percentage or factor applied to the ceding company's subject premium to produce the reinsurance premium or the percent applied to the reinsurer's premium to produce the commission.

Rate On Line - Same as payback, except that the price is quoted as a percentage of the limit. Thus, a 20 percent rate on line would be equivalent to a five year payback.

Regression - Regression analysis is the study of the dependence of one variable (the dependent variable), on one or more other variables (the explanatory variables), with a goal of estimating and/or predicting the mean or average value of the former in terms of the known or fixed values of the latter.

Reinstatement - A provision in an excess of a loss reinsurance contract, particularly catastrophe and clash covers, that provides for reinstatement of a limit which is reduced by the occurrence of a loss or losses. The number of times that the limit can be reinstated varies, as does the cost of the reinstatement.

Reinsurance - The transaction whereby the assuming insurer, for a consideration, agrees to indemnify the ceding company against all, or a part, of the loss which the latter may sustain under the policy or policies which it has issued.

Reinsurance Premium - The consideration paid by a ceding company to a reinsurer for the coverage provided by the reinsurer.

Reinsurer - The insurer which assumes all or a part of the insurance or reinsurance risk written by another insurer.

Reserve - An amount which is set aside to provide for payment of a future obligation.

Retention - The amount of risk the ceding company keeps for its own account or the account of others.

Retrocession - A reinsurance transaction whereby a reinsurer (the retrocedant) cedes all or part of the reinsurance risk it has assumed to another reinsurer (the retrocessionaire).

Return period - The expected length of time between recurrences of two events with similar characteristics. The return period can refer to hazard events such as hurricanes or earthquakes, or it can refer to specific levels of loss (e.g. a $100 million loss in this territory has a return period of 50 years).

Richter scale - The original magnitude scale developed by Charles Richter in 1935. Usually referred to as local magnitude, this scale is still often used by scientists for events less than M7.0. The term is often misused in the media to refer to earthquake magnitudes measured using other scales. See "earthquake magnitude" for more explanation of earthquake measurement scales.

Risk - A measure of potential financial loss, commonly encompassing two factors: exposure or elements at risk (amount of value subjected to potential hazard), and specific risk (the expected degree of loss due to a particular natural phenomenon). Also used more generally in insurance markets to refer to a specific property covered by an insurance or reinsurance policy.

Risk management - Management of the varied risks to which a business firm or corporation might be subject. It involves analyzing all exposures to gauge the likelihood of loss and determining how to minimize losses by such means as insurance, self-insurance, reduction or elimination of risk or the practice of safety and security measures.

Risk premium - The portion of the insurance rate or premium intended to pay for insured loss under the insurance policy, for the cost of repairing or rebuilding the damaged property. It does not include adjusting expenses, underwriting expenses, or profit, other contingencies and inflation, which insurers add to the loss cost to obtain a final rate. Risk models are often used to quantify loss costs for insured perils.

Riverine - Geographical area covered by a river, as well as the area surrounding the river, that might be affected by flooding and other water damage from the river.

Rupture length - The rupture length represents the total length of a fault that shifts during an earthquake. While the hypocenter is a point location, an earthquake is actually the result of rupture across an area of a fault. For large earthquakes this can result in movement continuing from the hypocenter to a considerable distance along the fault.

Saffir-Simpson scale - Scale commonly used to measure windstorm intensity. Uses a range of 1 to 5, with 5 being the most intense storms. Named after Herbert Saffir and Robert Simpson.

Secondary characteristics - Characteristics of a structure (other than the primary characteristics) that can be specified to differentiate vulnerability, such as year of upgrade, soft story, setbacks and overhangs, torsion, and cladding.

Secondary peril - Hazards that are an additional source of potential loss, commonly associated with a primary hazard. Examples include storm surge that accompanies a hurricane, fires that accompany an earthquake, or flooding that accompanies a windstorm.

Secondary uncertainty - While primary uncertainty measures uncertainty in the likelihood that a particular event occurs, secondary uncertainty incorporates the distribution of potential loss amounts for the event. In other words, it recognizes that when an event occurs, there is a range of possible loss values. The inclusion of secondary uncertainty produces smoother EP curves with longer tails; a longer tail on the curve indicates a positive probability that losses exceed a maximum event.

Seismic source - A region or geologic feature considered to have the potential to generate earthquakes.

Seismicity - The occurrence of earthquake activity.

Site - Same as location. When defining exposure data, a site may represent multiple buildings in close proximity that are of similar construction, and have a single deductible amount.

Slosh - Sea, lake, and overland surge from hurricanes/windstorms. The U.S. National Meteorological Center's computer model for calculating how much surge a windstorm will cause at any place along a coast.

Stochastic storm - A possible storm scenario created as part of a probabilistic model, the probability of which has been assigned using probability distributions from the historical record.

Storm surge - Quickly rising ocean water levels associated with windstorms, which can cause widespread flooding. Measured as the difference between the predicted astronomical tide and the actual height of the tide when it arrives. This difference arises in response to the lower barometric pressure associated with tropical or extra-tropical cyclones, and the action of the wind in piling up the surface of the water. The amount of surge depends on a storm's strength, the path it is following, and the contours of the ocean and bay bottoms as well as the land that will be flooded.

Subduction zone - Areas along tectonic plate boundaries where one plate is moving downward relative to the opposite plate. Also known as a Benioff zone.

Surface friction - The slowing effect on wind speed caused by vegetation or structures above ground level.

Tail - Commonly used to refer to the portion of the exceedance probability (EP) curve that represents very low probability of loss, but very high levels of loss.

Terrain - The topography as represented by changes in elevation; terrain can have an effect on many hazards, including localized wind speeds in storms and landslide susceptibility in earthquakes.

Track - The movement of the center of a low-pressure system such as a hurricane.

Track angle - The direction in which a storm travels (theta).

Tropical cyclone - A low-pressure system that develops in the tropics, in which the 1-minute sustained surface wind has reached 74 miles per hour (119 km/hr) or greater. Called a "hurricane" in the Atlantic and eastern Pacific, a "typhoon" in the western Pacific, and a "cyclone" in the south Pacific and Indian Ocean.

Tropical storm - A low-pressure system that develops in the tropics, in which 1-minute sustained surface wind ranges from 39 to 73 mph (63 to 118 km/hr).

Typhoon - See "tropical cyclone."

Validation - Process by which probabilistic models and assumptions are reviewed and compared to empirical data (such as historically observed losses or insurance claims) to confirm that the model approach and assumptions generate reasonable estimates of potential loss.

Vulnerability - Degree of loss to a system or structure resulting from exposure to a hazard of a given severity.

Vulnerability curve - A set of relationships that defines how structural damage varies with exposure to differing levels of hazard (such as ground motion or wind speed).

Wind speed - The speed of the wind during a windstorm.

Windfield - The time-integrated pattern of peak gust wind speeds experienced during the passage of a storm.

Windstorm - Generic term referring to low-pressure systems of various types that cause high winds and resulting damages. These include tropical cyclones (hurricane, typhoon, cyclone), extra-tropical cyclones, tornados and other convective systems.