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The Causes of Social Vulnerability to Coastal Hazards in Southeast Asia

Lele Zou and Frank Thomalla

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THE CAUSES OF SOCIAL VULNERABILITY TO COASTAL HAZARDS IN SOUTHEAST ASIA

An SEI Working Paper

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Executive summary

Several decades of research have produced considerable understanding of the complex interacting factors contributing to social vulnerability to natural hazards., Despite these insights and the efforts of the disaster risk reduction and humanitarian organisations to reduce hazard vulnerability, natural hazards remain a considerable challenge to poverty reduction and development in many countries around the world and particularly in South and Southeast Asia.

The objective of this project is to undertake a comprehensive, systematic analysis of the scientific literature on coastal hazards to identify the factors contributing to hazard vulnerability, determine the relationships between them, and to review recommendations for vulnerability reduction. The synthesis includes research findings from Bangladesh, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and Vietnam.

A meta-analysis methodology is applied, including the development of a system for coding information, statistical characterization, and the synthesis of key findings. The coding is restricted to the analysis of peer-reviewed scientific journal articles and employs a structure based on a review of the main conceptual frameworks on hazard vulnerability. The selected documents are characterized in terms of the disciplinary and geographical affiliations of the authors, their epistemological approaches and methodologies, and the focus of their work within the disaster risk reduction cycle. In 128 selected articles, a total of 336 vulnerability factors and 227 recommendations are identified and analyzed.

Several key findings arise from this synthesis:

- There is a clear gap between conceptual and theoretical work and empirically based case studies where deployment of, or even reference to particular conceptual frameworks are rare.
- Secondly, partly as a result of the existing gap, there seems no clear pattern or causal structure emerging from the reviewed research, with all the factors interwoven in a complicated way. Interpretations of how these factors interact to produce social vulnerability to coastal hazards in different environmental, historical, and social contexts are still largely idiosyncratic.
- Thirdly, and most importantly, there are mismatches between causal factors producing social vulnerability and the recommendations for its reduction and management, with most of the recommendations failing to target the underlying factors while focusing on short-term relief.

This work highlights the need for a multi-scaled and multi-disciplined research approach that addresses the gaps between field-based case studies, larger-scale vulnerability assessments, conceptual frameworks and theory, and the implications for policy and practice.

Main findings

The most important causes of vulnerability to coastal hazards

Factors relating to demography were the most frequently mentioned causes of vulnerability in the selected literature. Population growth was the highest ranking single cause of coastal hazard vulnerability. Population density, migration, and habitation of marginal and hazardous areas were also frequently mentioned factors. Demography affected almost all other factors of vulnerability. The second most important group of factors were related to human conditions and basic rights, particularly national and individual poverty, lack of access to resources, and inequality. Human conditions and basic rights issues were seen to strongly influence many other causes of vulnerability. On the other hand, poverty, lack of access to resources and inequality were in turn considered to be important drivers of demographic processes, particularly migration.The process of globalization and liberalization, exacerbates these factors.

Population dynamics

Migration is considered one of the most important factors contributing to hazard vulnerability. Economic migration in Southeast Asia is thought to be one of the main causes of over- exploitation of natural resources and environmental degradation. Market liberalization and economic globalization

create opportunities and growth in the region and exacerbate the existing inequalities and tensions over access to resources. Migration occurs also at national, sub-national and local levels, where poor people living in rural communities move to other rural communities or urban areas to gain better access to natural resources, employment opportunities and education. Migration to the coast leads to population growth and increasing population density in coastal areas. This in turn increases the demand on coastal resources and leads to over-grazing, slash and burn farming, deforestation and intensive use of floodplains and wet lands. The increasing demand for land also leads to higher land prices, overdevelopment and inappropriate landuse policies with far-reaching consequences in many other areas.

Development

The meta-analysis indicates that factors relating to "Development" and "Infrastructure" are closely linked to socio-economic processes. In the countries considered in this analysis, economic development is of high priority and socio-economic changes are occurring rapidly. These countries have high socio-economic vulnerability because they depend heavily on agricultural production and are characterized by extremely uneven access to resources and high levels of national and individual poverty. Traditional small-scale and subsistence farming is increasingly being replaced by large-scale commercial agricultural production. Crop diversification and intensification, as well as landuse changes through industrial development and urbanisation are in many places leading to profound changes in geographical and environmental characteristics. Infrastructure development, such as the construction of flood embankments, artificial channels and reservoirs, transforms the environment and affects ecosystem functioning and ecosystem services.

The role of institutions in creating and perpetuating vulnerability

Institutions, both explicitly and implicitly, determine the power structure within a given society and hence the distribution of social and natural resources. Our analysis indicates that factors relating to institutions affect almost all other causes of vulnerability to coastal hazards, ranging from the choice of development pathways and practices to demographical dynamics and poverty and marginalisation. Institutional structures and characteristics are defined to some extent by social culture. Social culture consists of people's perceptions and the social structure, both of which are the results of longer-term historical processes.which involve aspects such as religion, history, values and social norms. These have a profound effect on hazard vulnerability.

Cooperation and power relations

The extent and effectiveness of cooperation between different actors is not only determined by the need to share information, but also by the expectations and intentions of different stakeholders and the power relations between them. The distribution of power underlies the structure of society and this structure influences many aspects of social systems, including cooperation. Cross-level cooperation is often motivated either by the potential benefits to particular stakeholders or the high costs of not undertaking them. The essence of this kind of cooperation between decision-makers and communities is the linkage between resource users and government agencies, which indicates the unevenness of right allocation. Good cooperation between the government authorities and civil society, enables everyone, and involves the decentralization of power and control over resources, which is a process that requires the willingness of national governments to reduce their own power.

The most important recommendations to reduce vulnerability

Increase hazard awareness and knowledge

Our analysis indicates that increasing hazard awareness and knowledge was the most frequently made recommendation to reduce hazard vulnerability. Individual recommendations included calls to

increase awareness of potential hazards, to establish appropriate response and coping strategies, and to conduct periodical emergency drills. Such measures tended to be targeted particularly at poor people living in rural coastal communities and people who have recently migrated to coastal areas. The main suggested channels for achieving these aims were school programmes and media campaigns. Also increasing general literacy was seen as a way to develop awareness.

Improve early warning systems and evacuation procedures

Effective early warning systems were considered to be an important component of disaster preparedness and response, in reducing the potential losses from disasters. Many recommendations in this area focused on the improvement of risk assessment methodologies and early warning systems. There was a clear emphasis, however, on improving the technological "hard" elements of such systems with little consideration of the "soft" components, such as appropriate mechanisms for the communication and dissemination of early warning information to end-users and the linkages with community-based disaster preparedness activities.

Improve communication and cooperation

Our analysis revealed a strong need to improve cooperation and communication between the many different actors operating in areas and sectors relevant to reducing hazard vulnerability. This need applies to both vertical and horizontal cooperation. Vertical cooperation refers to cooperation between authorities and communities and includes the sharing of information, as well as the sharing of control over power and resources, through the participation of local communities in the decision making process. Horizontal cooperation refers to cooperation between different government authorities and between such authorities, with other stakeholders, such as non-governmental and civil society organizations and researchers.

Strengthen environmental protection and post-disaster rehabilitation

It is now widely acknowledged that the state of the environment is an important component of human well-being and sustainable development. As the understanding of the interactions between human activities and natural processes within coupled human-environment systems improves, the calls for strengthening environmental governance and undertaking post-disaster rehabilitation of affected ecosystems become increasingly louder. Researches indicate that human vulnerability and livelihood security are closely linked to biodiversity and ecosystem resilience. The role of resilient ecosystems in underpinning resilient social systems and hence decreasing vulnerability to natural hazards, is related to the capacity of ecosystems to buffer the impacts of extreme events. Healthy ecosystems are also able to provide more options for communities to assist with livelihood recovery following a disaster.

Integrate disaster risk reduction into sustainable development strategies

Because disasters are increasingly becoming a global challenge for sustainable development, there is an urgent need to develop strategies that integrate, more strongly, disaster risk reduction with natural resource management, poverty reduction and sustainable development. Overexploitation and degradation of coastal ecosystems increase hazard exposure, reduce livelihood options, and reduce the potential for economic recovery after a disaster. These relationships indicate the importance of developing strategies for sustainable development that incorporate the building of ecological and social resilience to environmental and other shocks and surprises.

Gaps in existing research

The analysis of the state of scientific understanding of the causes of hazard vulnerabilities and the recommendations put forward by researchers to reduce these vulnerabilities, revealed important shortcomings in the relevance of existing scientific research in providing appropriate and relevant

information for policy and practice. Gaps exist, in particular, in the application of conceptual thinking in vulnerability assessment, the development of operational methodologies relevant for actors at the sub-national level, and the formulation of concrete recommendations that address the systemic underlying causes of vulnerability.

Limited understanding of vulnerability patterns

A wealth of empirical case studies on risk and vulnerability has been undertaken at levels ranging from household to global.. The experience in undertaking such assessments is diverse and the findings are highly context and place specific. Understanding of the causal structures and dynamics of vulnerability is still far from comprehensive and systematic. To date, very few rigorous comparative studies that aim to synthesize this collective experience have been undertaken. Recently, progress has been made in improving integrative analysis of vulnerability and human well-being in the context of environmental risks and change.

With respect to coastal hazards, many studies have been undertaken during the last few decades and a considerable number of them focus on Southeast Asia. However, there have been few attempts to investigate comprehensively the underlying factors and pathways through which social vulnerability to coastal hazards is constructed, and this is the first systematic review based on the analysis and comparison of a large number of case studies. In this analysis conceptual linkages between different causes could be established, but we found that many different interpretations of how these factors interact to produce vulnerability exist, depending on the scale of analysis and the specific environmental, historical, and social contexts of the particular case. More research is therefore required to facilitate the systematic assessment of vulnerability across different sectors and geographical scales.

Recommendations ignore the most important underlying causes of vulnerability

Many of the factors considered most important in creating hazard vulnerability relate to social structure and the underlying processes of societies that determine power relationships and access to resources. These factors contributing to vulnerability to coastal hazards (demography, poverty and marginalization) are inherent characteristics of human society, affecting vulnerability through multiple pathways and processes. Addressing these factors involves challenging the existing structures and power relationships of today's societies.

Rather than using these factors as a starting point in developing strategies for reducing vulnerability, most of the recommendations are concerned with measures that assist coping with and responding to, the hazard event itself. Whilst such recommendations make an important contribution in the reduction of the potential impacts of hazards, they do not address the underlying systemic causes of vulnerability. For example, improving hazard knowledge might help people living or working in exposed coastal areas to prepare for the impacts of potential hazards, but it does not address the reasons why these people have no choice but to live in such areas in the first place.

Gaps between assessment, policy and practice

The links between vulnerability assessment and policy development are extremely weak, as most assessments are undertaken at national, regional and global levels which have limited relevance to sub-national level.decision makers Ineffective communication between different stakeholders, relating to all phases of the disaster risk reduction cycle, was identified as one of the main factors contributing to vulnerability. Whilst many authors demonstrate the need to improve information sharing between different actors, to increase hazard awareness amongst the public, and to improve the dissemination and communication of early warnings, most recommendations are so general that they are of limited value in formulating appropriate and effective disaster risk reduction strategies and policies. This indicates that there is an urgent need to improve and apply methods to assess vulnerability and to produce policy-relevant findings that better inform disaster risk reduction efforts. Whilst the con-

cept of vulnerability is widely used amongst researchers, policymakers and practitioners, it is rarely defined or applied.

Lack of primary data and limited substantiation of arguments

Most of the papers focused on general institutional policies or integrated management approaches for water-related hazards. Only a small number of studeies were concerned with concrete aspects of disaster risk reduction or specific practical implementation measures. In the absence of relevant data and substantiated arguments, many documents fail to contribute to our understanding of who is vulnerable and why, and what measures might be most appropriate and effective in reducing hazard vulnerability.

Lack of conceptual frameworks in guiding vulnerability case study analysis

There is a tremendous gap between conceptual and theoretical work on vulnerability and empirically based case studies. The selected works include a large number of local case studies of coastal hazard vulnerability but none of these employed a conceptual or theoretical framework to guide the analysis. There are very few links in the literature between theoretical thinking and the context-specific richness of experience and knowledge derived from local case studies.

Lack of consideration of different perceptions of risks and vulnerabilities

Many existing and recommended disaster risk reduction strategies do not take into account the perceptions and situations of people that are at risk from coastal hazards. Even though many measures to help people to build their capacity to cope with hazards exist, they are frequently not effective because they do not address the realities people face in their everyday lives.

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1. INTRODUCTION

1.1 Background and context

Several decades of research have led to an improved understanding of the complex and interacting factors that contribute to the construction of social vulnerability to natural hazards (Kasperson and Kasperson, 2001; Turner et al., 2003; Pelling, 2003; Kasperson et al., 2005; White et al. 2001; Birkmann, 2006). Despite these insights, a growing awareness of natural hazards amongst the general public, through extensive media coverage (Berz et al. 2001; White et al. 2001), and the efforts of the disaster risk reduction and humanitarian communities (e.g. IDNDR, Yokohama Declaration 1994, the Hyogo Framework for Action 2005-2015) to reduce hazard vulnerability, the impacts of natural disasters have grown significantly over the last few decades (Yodmani 2004) and remain a considerable challenge to poverty reduction and sustainable development in many countries around the world.

A wealth of empirical case studies on risk and vulnerability has been undertaken at scales ranging from household to global level. The experience in undertaking such assessments is diverse and the findings are highly context and place specific (Turner et al. 2003). Because the characteristics of different locations can vary considerably, some researchers (e.g. Weichselgartner and Bertens 2000; Cannon et al. 2003) argue that each disaster situation is unique. Also, the understanding of the causal structures and dynamics of vulnerability remains patchy and anecdotal, despite the advances of vulnerability research during the past two decades (Adger et al., 2005; Kasperson 2006). To date, very few rigorous comparative studies that aim to synthesise this collective experience have been undertaken. Examples are the work of Misselhorn (2006) in the area of food insecurity in Southern Africa and that of Geist (2004) and Geist and Lambin (2004) in the area of land cover change.

More such systematic analyses are urgently needed to determine typical patterns of vulnerability and policy response in different contexts. Recently, some progress has been made in improving integrative analysis of vulnerability and human well-being in the context of environmental risks and change. The UNEP Global Environment Outlook (GEO)-4 Chapter 7 "Vulnerability of Human-Environment Systems: Challenges and Opportunities" (Jäger et al., 2007) describes specific representative patterns of the interactions between environmental change and human well-being. These so-called "Archetypes of Vulnerability" aim to illustrate the basic processes whereby vulnerability is produced and to enable policymakers to recognize their particular situations within a broader context, providing regional perspectives and important connections between regions and the global context and insights into possible solutions. The GEO-4 archetype approach is inspired by earlier work at PIK for the German Advisory Council on Global Change on the "Syndromes of Global Change" that describes non-sustainable patterns of human-environment interaction, and analyses the dynamics behind them (Lüdeke et al., 2004; Lüdeke and Petschel-Held, 1997; Schellnhuber, 1998; Schellnhuber et al., 1997, 2002), but is broader as it includes opportunities offered by the environment to reduce vulnerability and improve human well-being (Jäger et al., 2007; Wonink et al., 2005; Thomalla et al., 2006).

The definition and description of the GEO-4 archetypes is highly qualitative and based on a mixture of expert judgment and priorities identified by regional representatives. There is a clear need for systematic comparison of case studies to uncover the elements of effective vulnerability reduction policy to inform decision making in particular situations. This requires a methodology that is capable of describing and quantifying such patterns better, in order to support accurate communication within and between different academic communities and practitioners, and to eliminate misunderstandings that result from the use of ambiguous terminology. Such a methodology would facilitate the systematic assessment of vulnerability across different sectors and geographical levels, improve the clarity of communication on vulnerability and provide a basis for computational modelling.

With respect to coastal and hydro-meteorological hazards, many studies have been undertaken during recent decades and a considerable number of them focus on Southeast Asia. These studies range from impact studies on coastal ecosystems and physical infrastructure to studies of social vulnerabil-

ity. Though many studies on coastal hazard risks exist, they have mainly focused on the following aspects:

- National-level analysis of fatalities caused by water-related disasters (Coates 1999; Parsuraman and Unnikrishnan 2000; Wright 2000). For example, (Coates 1999) analyzed the flood fatalities from 1788 to 1996 in Australia, while (Parsuraman and Unnikrishnan 2000) focused on India;
- Statistical analysis of disaster fatalities and affected people (Berz, Kron et al. 2001) documented the general statistics of different natural disasters at global level,. (Jonkman 2005) investigating the loss of human life for different types of floods and different regions.
- The relationship between disaster fatalities and national macro social-economic factors such as GDP and population size (Haque 2003). In addition, there has been a considerable amount of research on the impacts of natural disasters on human society, including the impacts on economic systems, on nutrition and health care, and on people's livelihoods (Keipi and Tyson 2002; Doswell 2003; Ninno and Lundberg 2005).

However, there have been few attempts to investigate comprehensively the underlying factors and pathways through which social vulnerability to natural hazards is constructed and no systematic review based on the analysis and comparison of a large number of case studies has been undertaken to date.

1.2 Objectives

The objective of this project is to undertake a comprehensive systematic analysis of the scientific literature on social vulnerability to coastal hazards in South and Southeast Asia, in order to identify the factors contributing to hazard vulnerability, to determine the relationships between them, and to review recommendations made for reducing vulnerability to coastal hazards. By drawing from key lessons learned from several decades of accumulated experience we aim to identify current gaps in knowledge, as well as gaps in the interface between science, policy and practice.

The following research questions were identified to guide the analysis:

- How can the current knowledge on coastal hazard vulnerability be characterized?

  This question relates to the production and ownership of knowledge and includes questions such as what types of assessments are undertaken, and who undertakes them?.
- What methods are used to assess vulnerability?

  How is vulnerability conceptualized and defined? What methods are used in vulnerability assessment? At what spatial and temporal scales is the assessment undertaken? Which geographical locations are in focus? What indicators are used to describe vulnerability?
- What is the current state of knowledge?

  How does vulnerability manifest itself in particular locations and situations? Which locations, individuals and social groups are particularly vulnerable and why? What are the key factors contributing to their vulnerability? How do multiple factors interact? What processes occur at what levels and what is their relative importance?
- To what extent is vulnerability specific to location, situation, ecosystem, or sector?Is there a systematic causal structure of vulnerability? Are there common elements or typical patterns of vulnerability and policy response that can be characterized, formalized and transferred to similar situations in other regions?

What are the key lessons for policy to reduce hazard vulnerability?

Does a systematic synthesis of existing knowledge reveal new insights and lessons for reducing vulnerability and building resilience to coastal hazards? What are the disparities between research, policy and practice on disaster risk reduction? What new knowledge is needed to support more effective decision-making?

1.3 Natural hazards

1.3.1 Global occurrence and impacts

Natural hazards have always been an important part of human history and remain one of the main challenges for human well-being and sustainable development in many parts of the world to date. In 1995, natural disasters claimed 88,835 lives and affected 161 million people world-wide (IFRC, 2006). Between 1980 and 2000 some 75 percent of the world's population lived in areas affected at least once by an earthquake, a tropical cyclone, a flood or a drought (UNDP, 2004).

Table 1.1: Thirty years of natural disaster[1] impacts: 1970-2006

Decades	1970 - 79	1980 - 89	1990 - 99	2000-06
People reported killed (million)	1.96	0.80	0.79	0.52
People reported affected[2] (billion)	0.74	1.45	1.96	1.71
Estimated economic losses (billion $US)[3]	131.00	204.00	629.00	582.23
Number of reported disasters	1110	1987	2742	3248
Ratio of killed/per million affected	2648.65	551.72	403.06	3040.93
Ratio of killed/per reported disaster	1765.77	402.62	288.11	160.10
Ratio of affected (thousand) /per reported disaster	666.67	729.74	714.81	526.48
Ratio: economic loss (million $US)/ per reported disaster	118.02	102.67	229.39	179.26

Based on sources: Munich Re; EM-DAT, CRED, University of Louvain, Belgium

1.3.2 Hazard types and regional distribution of disasters

There are considerable differences in the incidence and impacts of different hazard types in different world regions. More than 90 per cent of the people exposed to disasters live in the developing world (ISDR, 2004) and more than half of disaster deaths occur in countries with a low human development index (White et al., 2005). Between 1993 and 2002, two-thirds of all recorded disasters were hydro-meteorological disasters, such as floods (37 percent) and windstorms (28 percent) (Table 1.2). Floods were the most frequent natural disaster, killing nearly 100,000 people and affecting more than 1.2 billion people world-wide (Munich Re, 2004). In terms of the number of people affected, the most important disasters during this time period were floods (56 percent), drought/famines (29 percent), and windstorms (13 percent). Earthquakes caused 37 percent of the estimated socio-economic damage, followed by floods (32 percent), and windstorms (20 percent). (Table 1.2)

In terms of the regional distribution of the disasters recorded between 1993 and 2006, 55 percent of all people killed by natural disasters and 91 percent of all people affected lived in Asia.By contrast, the Americas and Europe had a combined share of ca. 17 percent of all people killed and less than 3 percent of all people affected (Table 1.3).

1 In order for a disaster to be entered into the EM-DAT at least one of the following criteria has to be met: a) 10 or more people reported killed; b) 100 people reported affected; c) call for international assistance , and / or d) declaration of a state of emergency.

2 Affected: people requiring immediate assistance during a period of emergency. Defining 'affected' is extremely arduous. Figures will always rely on estimates, as they are many different standards, especially in major famines.

3 Source, Munich Re, in 2000 prices.

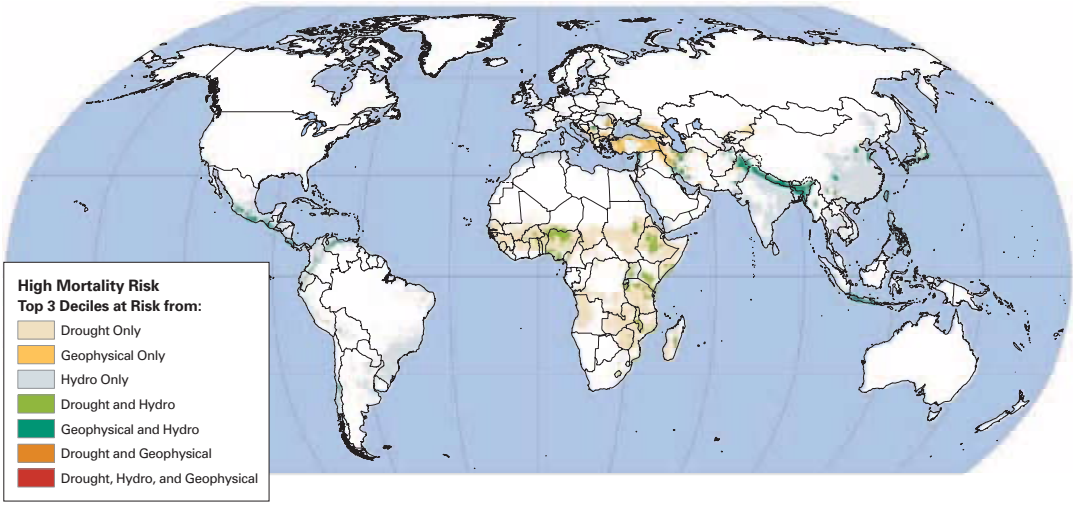

Figure 1.1: Global distribution of highest risk hotspots by hazard type (Dilley et al., 2005)

Table 1.2: Distribution of natural disaster impacts by type: 1993 - 2006[4]

	% of reported disasters	% of people reported killed	% of people reported affected	% of Estimated damage[5]
Avalanches/landslides	4.23	1.21	0.11	0.14
Drought/famines	5.24	0.32	26.70	4.06
Earthquakes	9.21	58.34	1.58	21.95
Extreme Temperature	5.31	13.15	0.33	1.86
Floods	43.64	16.77	56.47	26.58
Forest/scrub fires	4.51	0.11	0.11	2.49
Volcanic eruptions	1.77	0.10	0.04	0.08
Windstorms	28.04	11.48	12.52	20.23
Other	0.85	0.51	0.00	0.04
Hydro-meteorological disasters[6]	93.21	84.65	94.69	64.01
Geophysical disasters[7]	6.79	15.35	5.31	36.99
Total natural disasters	5433	824656	3256.4 million	1143.5 billion $US

Source: EM-DAT, CRED, University of Louvain, Belgium

4 The number in the table is calculated as the percentage share of each type of natural disaster of the total reported: number of disasters, people killed, people affected, and amount of estimated damage.

5 Estimated damage: the economic impact of a disaster usually consists of direct damage (e,g., to infrastructure, crop, housing) and indirect damage (e,g., lose of revenue, unemployment, market destabilization).

6 Including avalanches/landslides, drought/famines, extreme temperatures, floods, forest/scrub fires, windstorms, and others mainly including biologic hazards such as epidemic.

7 Including earthquakes and volcanic eruptions.

Table 1.3: Distribution of natural disaster impacts by continent: 1993 – 2006[8]

	% of reported disasters	% of people reported killed	% of people reported affected	% of Estimated damage
Africa	22.67	28.03	5.43	1.97
Americas	18.49	7.21	1.72	28.57
Asia	35.70	54.86	91.22	33.63
Europe	19.43	9.57	1.09	35.03
Oceania	3.72	0.33	0.54	0.80
Total (abs. number)	2935	531159	2496.2 million	654.6 billion $US

Source: EM-DAT, CRED, University of Louvain, Belgium

Considering that the number of hydro-meteorological disasters in Asia account for just over 35% of the world total, Asia experiences disproportionally high losses in terms of the number of people killed and affected, as well as the amount of damage (Table 1.4). Owing to population growth (between 1981-1990 and 1991-2000 Asia's population increased by 63.5 million) the annual number of people in Asia affected by natural hazards continues to increase (Han 2004).

Table 1.4: Losses due to hydrometeorological disasters in Asia (Source: EM-DAT, CRED, University of Louvain, Belgium)

Hydrometeorological Disasters 1995 to 2006	Asia	World Total	Asia % of World
Total number reported	1274	3013	42.28
Total number of people killed	396713	504719	78.60
Total number of people affected (' 000)	2645163	2731464	96.84
Total amount of damage (million USD)	274930	513214	53.57

Figure 1.2 shows the ratio of the percentages of the number of reported disasters, the number of people killed and affected, and the estimated damage in Asia compared with the rest of the world between 1995 and 2004. Whilst the percentages of disasters reported and people affected were relatively stable, there were high inter-annual variations of the number of lives lost and the estimated economic damage. However, the number of people killed and the estimated damage showed a decreasing trend until about 2002/3 ,since when they have been increasing.

1.3.3 Trend in the number of reported disasters

Global datasets on extreme events indicate a significant increase in the number of reported natural disasters (EM-DAT; Munich Re NatCat Service, 2004; Munich Re, 2006). In the three decades from 1975 to 2005 disasters increased by a factor of 5 (Figure 1.3). Figure 1.4 shows the trend from 1991 to 2006 by disaster type.

8 The number in the table is calculated as the percentage share of each continent of the total reported number of disasters, people killed, people affected, and amount of estimated damage.

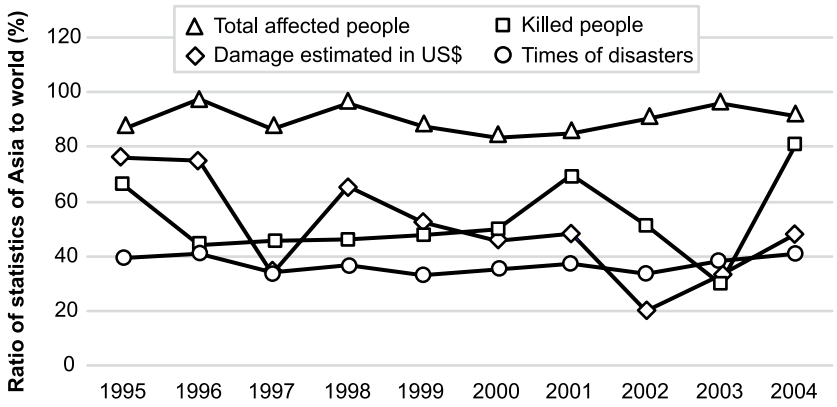

Figure 1.2: Natural disaster impact ratio of Asia compared to the rest of the world (1995-2004)

(Source: EM-DAT, CRED, University of Louvain, Belgium)

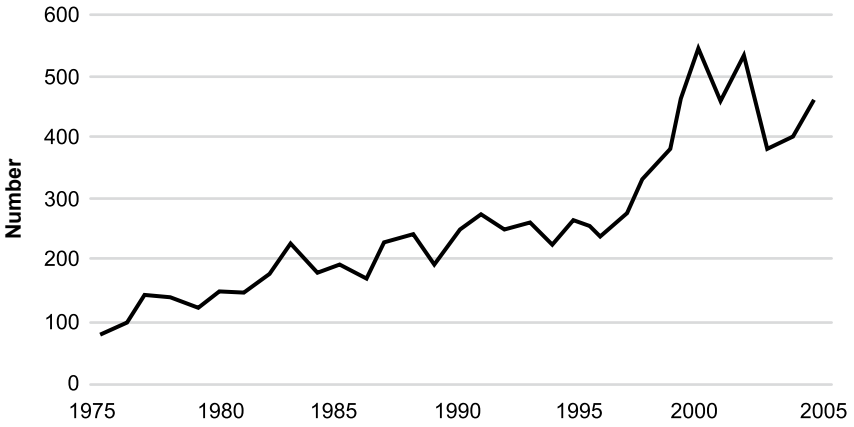

Figure 1.3: Time trend on frequency of country-level disasters 1975-2005

(Source: EM-DAT: The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels, Belgium)

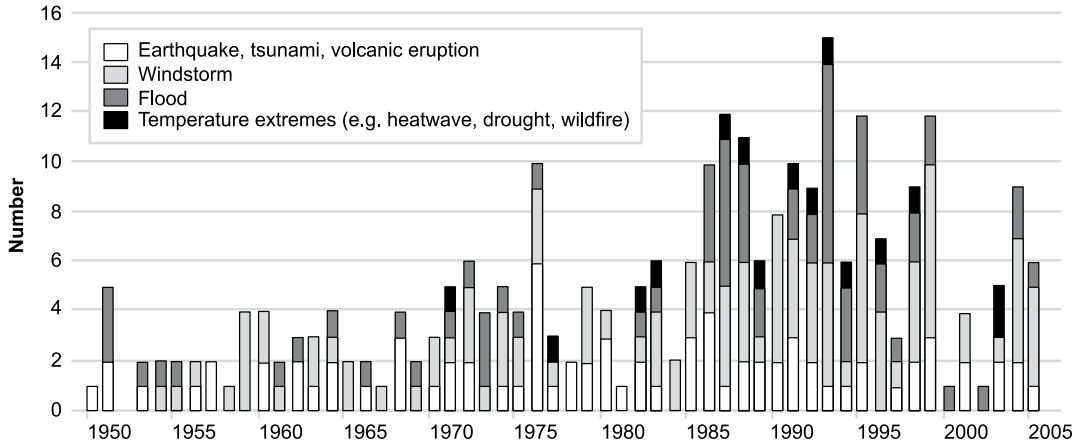

Figure 1.4: Number of reported natural disasters by type: 1991-2006

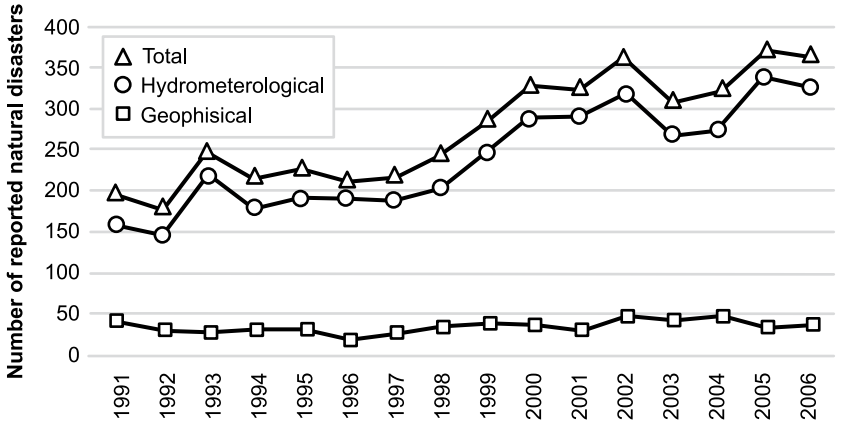

Figure 1.5: Number of great natural catastrophes by year and type of event (Munich Re, 2005)

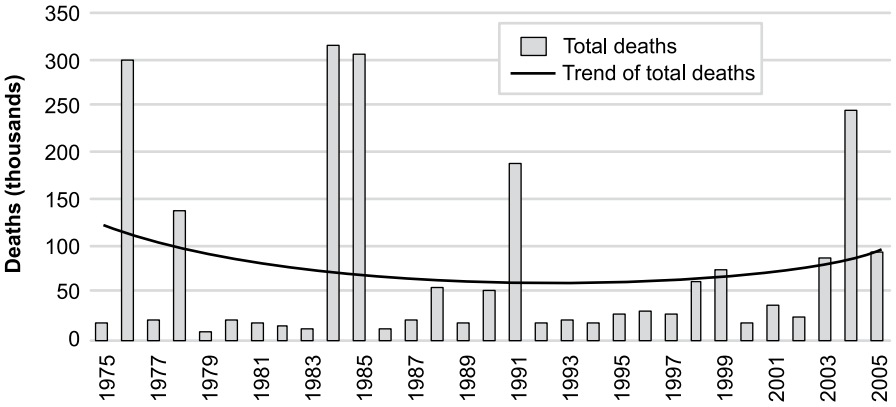

Figure 1.6: Number of people killed by natural disasters 1975-2005 (Source: EM-DAT: The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels,

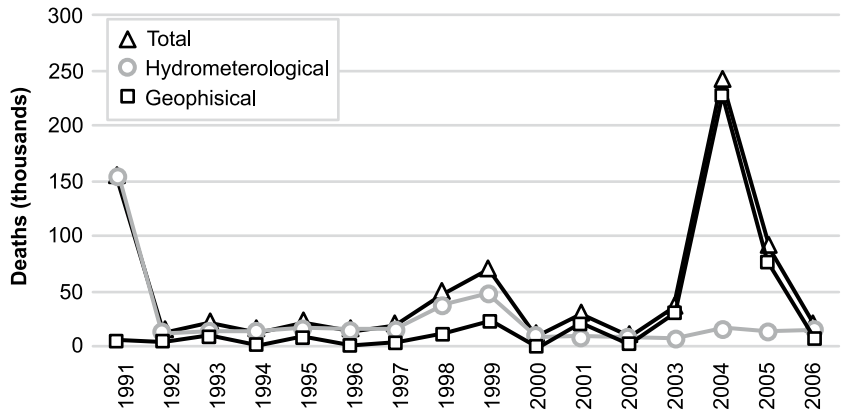

Figure 1.7: Number of people killed by natural disaster type: 1991-2002 (Han, 2004)

1.3.4 Trend in the number of people killed

Comparing the decades 1983-1992 and 1993-2002, reported global deaths from natural and technological disasters fell by 38 percent. Thus, the loss of human life due to natural disasters has clearly declined as a proportion of the population at risk, nevertheless it remains high. However, the number of people affected rose by 54 percent over the same period and it continues to rise to date (Figure 1.4). It is also notable that the largest economic losses do not always coincide with the largest number of people affected. This demonstrates a growing disparity between economic development and social vulnerability to natural hazards. In recent decades, the number of people at risk from natural hazards has grown by 70 to 80 million per year and more than 90% of this growth has occurred in developing countries.

1.3.5 Trend in the number of people affected

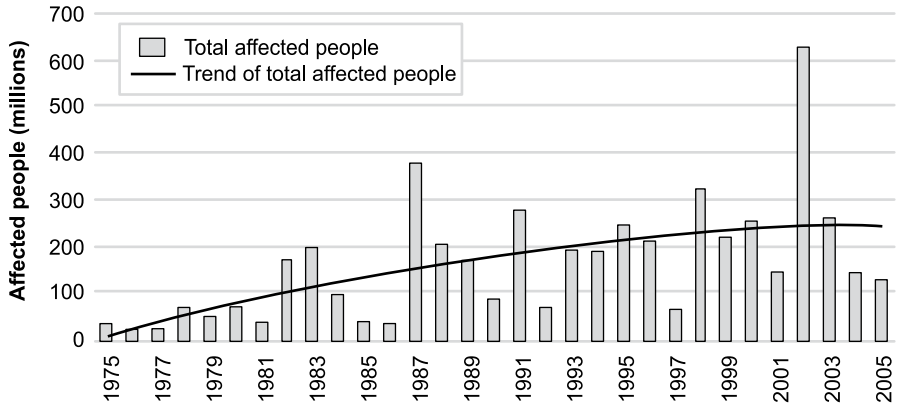

Figure 1.8: Number of people affected by natural disasters 1975-2005

(Source: EM-DAT: The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels, Belgium)

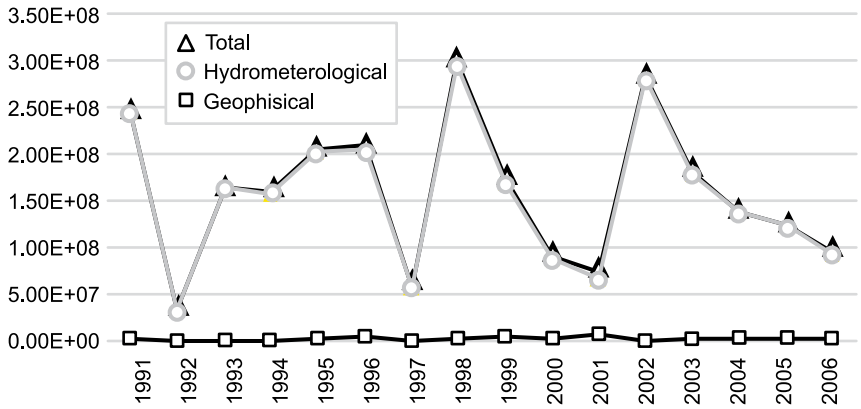

Figure 1.9: Number of people affected by natural disaster type: 1991-2006

1.3.6 Trend in economic damages

The EM-DAT global datasets on extreme events (Figure 1.10) indicate that annual economic losses from extreme events have increased tenfold from the 1950s to the 1990s. Munich Re (2004) documented an increasing concentration of the loss potential from natural hazards in mega-cities. Only a small proportion of these losses are insured.

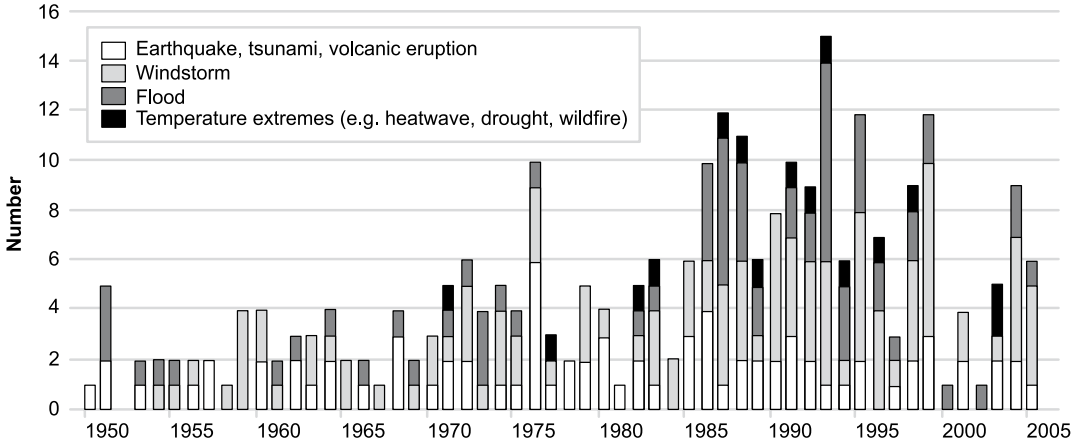

Figure 1.10: Overall losses and insured losses due to natural disasters between 1950 and 2005 adjusted to 2005 values

(Munich Re, 2006)

Box 1.1: Definition of terms related to hazard and disaster

Hazard: A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity, frequency and probability.

Natural Hazard: Natural processes or phenomena occurring in the biosphere that may constitute a damaging event. Natural hazards can be classified by origin namely: geological, hydrometeorological or biological.

Disaster: A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk.

Risk: The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions.

Conventionally risk is expressed by the notation: Risk = Hazards x Vulnerability. Some disciplines also include the concept of exposure to refer particularly to the physical aspects of vulnerability.

Source: ISDR, 2004, http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm

2. COASTAL DISASTERS

2.1 Definition

Coastal disasters can arise from natural processes such as weather-related (hydro-meteorological) and geophysical hazards, as well as from human actions. Hydro-meteorological hazards include tropical cyclones, storms, floods and hazards resulting from climate change, particularly sea-level rise (Klein and Nicholls, 1999). Geophysical hazards include earthquakes and associated tidal waves and tsunamis. Man-made hazards include pollution, transport and industrial accidents, harmful algal blooms and marine-related infectious diseases. Box 2.1 provides definitions of hydro-meteorological and geophysical hazards affecting coastal areas.

2.2 Global exposure to coastal hazards

Globally, 1.2 billion people (23 percent of the world's population) live within 100 km of the coast and this number is expected to increase to 50 percent by 2030 (Small and Nicholls, 2003). In a recent global assessment of storm surges, Nicholls (2006) estimated that in 1990 ca. 200 million people were living in areas vulnerable to storm-surge flooding. The North Sea, the Bay of Bengal, and East Asia are considered as notable hotspots, but other regions such as the Caribbean, North America, parts of East Africa, Southeast Asia and the Pacific are also vulnerable to storm surges (Nicholls, 2006).

46 million people per year are currently at risk from coastal flooding due to storm surges (IPCC, 2001) and 10 million people each year experience coastal flooding (Nicholls, 2004). Estimates of the number of additional people likely to be at risk from coastal flooding in the future vary widely but all indicate a considerable increase. For example, Nicholls (2006) expects the number of people living in areas vulnerable to storm surge flooding to increase by nearly 50 percent, or 290 million by the 2020s compared to 1990 while Parry et al. (2001) estimate about 30 additional million of people at risk from coastal flooding due to climate change for the 2050s, and 85 additional million for the 2080s.

2.3 Coastal disasters in South and Southeast Asia

2.3.1 Exposure and impacts

Compared with other parts of the world, Asia experiences a disproportionally high number of severe disasters. Coastal South and Southeast Asia are particularly affected by hydro-meteorological disasters. During the period 1993-2006, hydro-meteorological hazards accounted for 90 percent of reported disasters, 86 percent of the number of people killed, and 99 percent of the number of people affected

Box 2.1: Coastal hazards

Tidal wave: Abrupt rise of tidal water (caused by atmospheric activities) moving rapidly inland from the mouth of an estuary or from the coast.

Tsunami: Series of large waves generated by sudden displacement of seawater (caused by earthquake, volcanic eruption or submarine landslide); capable of propagation over large distances and causing a destructive surge on reaching land. The Japanese term for this phenomenon, which is observed mainly in the Pacific, has been adopted for general usage.

Cyclone (hurricane): Large-scale closed circulation system in the atmosphere above the Indian Ocean and South Pacific, with low barometric pressure and strong winds that rotate clockwise. Maximum wind speed of 64 knots or more.

Tropical storm: Generic term for a non-frontal synoptic scale cyclone originating over tropical or sub-tropical waters with organised convection and definite cyclonic surface wind circulation.

Source: CRED EM-DAT

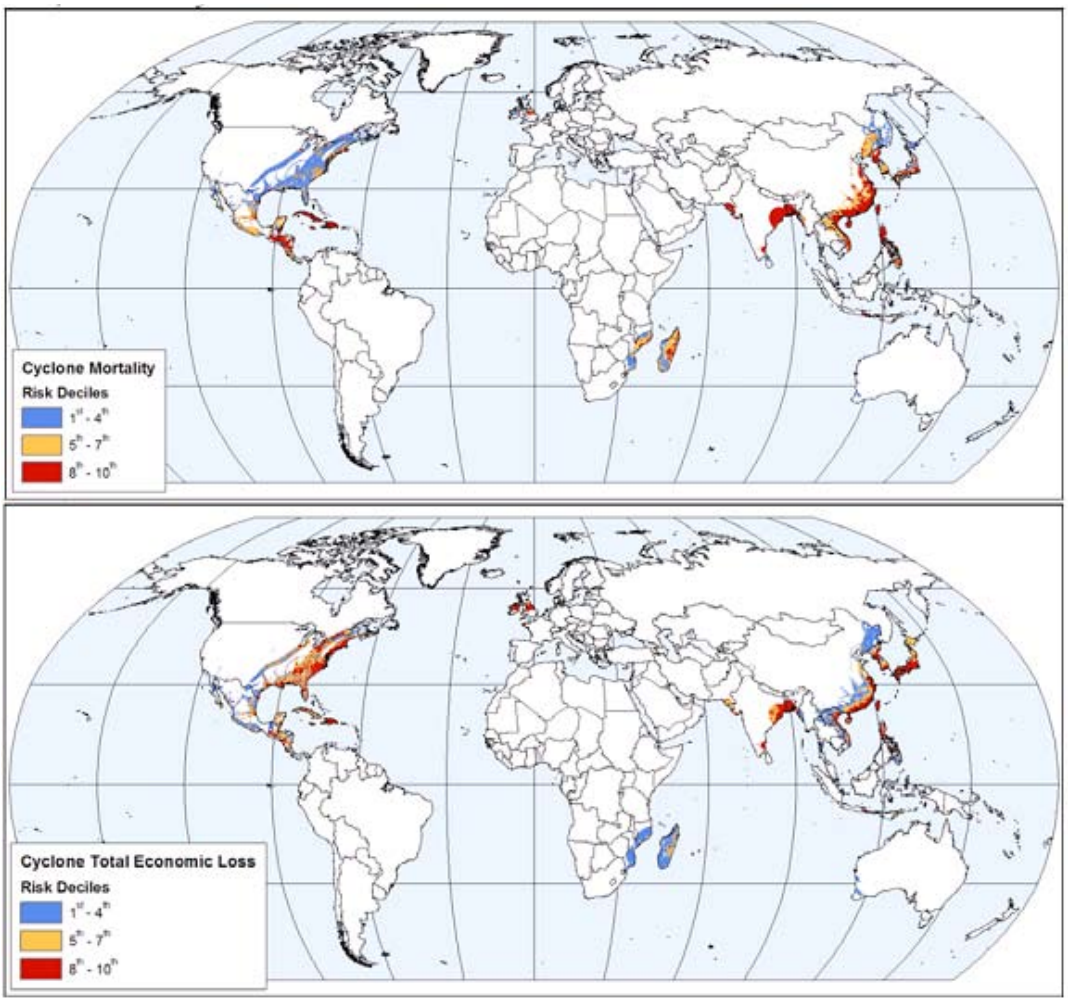

Figure 2. 1: Global distribution of cyclone risk: top: mortality, bottom: economic loss

(Dilley et al., 2005)

by disasters (Table 1.3). Floods are the most frequent type of disaster, accounting for 56 percent of all people affected and 32 percent of economic damage. Table 1.3 also shows that 79 percent of all people killed and 91 percent of all people affected by disasters during this time period lived in Asia. Between 1975 and 2001, most of the 45 floods with the highest number of people affected occurred in India and Bangladesh (S.N.Jonkman 2005). Table 2.1 shows the number of people killed and affected in the coastal countries of South and Southeast Asia between 1985 and 2006. These 8 countries alone accounted for 29.1 percent of the world total of the number of people killed and 56.67 percent of people affected.

Figures 2.2 and 2.3 indicate that although there appears to be no clear trend in the number of people affected in South and Southeast Asia since the 1970s, economic damage has increased considerably during this time period.

2.3.2 Vulnerability to coastal hazards

Vulnerability to hazards is a product of the complex and dynamic interaction of social, economic and environmental factors (Turner et al., 2001). Coastal hazards affect a wide range of ecological systems including forests, grasslands, wetlands, rivers, lakes, and marine environments, as well as human sys-

Table 2.1: Number of people killed and affected by coastal disasters in countries in South and Southeast Asia between 1985 and 2006

Country	Number of people reported killed 1985-2006	Number of people reported affected 1985-2006
Bangladesh	10,036	216.9 million
India	5,225	567.1 million
Indonesia	7,943	9.5 million
Malaysia	1,531	0.4 million
Philippines	31,202	71.4 million
Sri Lanka	34,907	6.5 million
Thailand	11,637	26.1 million
Viet Nam	10,517	40.3 million
S and SE Asia selected	128,142	1.7 billion
World Total	440,313	3.0 billion
% of world	29.10	56.67

(Source: EM-DAT, CRED, University of Louvain, Belgium)

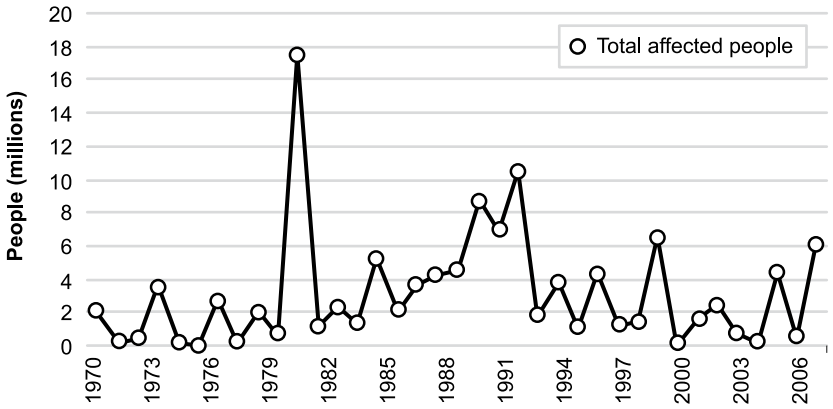

Figure 2.2: Total annual number of people affected by natural disasters in South and Southeast Asia 1970-2006

(Source: EM-DAT, CRED, University of Louvain, Belgium)

tems including agriculture, natural resources, health, financial institutions, and settlements. Operating on different spatial and temporal scales within the coupled human-environmental system, these processes give rise to vulnerability as they affect the ability of individuals and communities to prepare for, cope with, and recover from disasters (Turner et al., 2001).

As the statistics in Chapter 1 illustrate, natural hazard impacts are highly differentiated and unevenly distributed between regions. Certain countries, regions and areas are more vulnerable than others because of their geographic location, climate, geology and their capacity to cope with extreme conditions (Kasperson et al, 1995; Hewitt, 1997; Kasperson et al 2001).

Within communities affected by hazards, certain social groups and individuals are more vulnerable than others (Fordham, 1999). Those most vulnerable to natural hazards tend to be women, the elderly, children, ethnic and religious minorities, single-headed households; people engaged in marginal livelihoods; socially excluded groups such as 'illegal' settlers and others whose rights and claims to

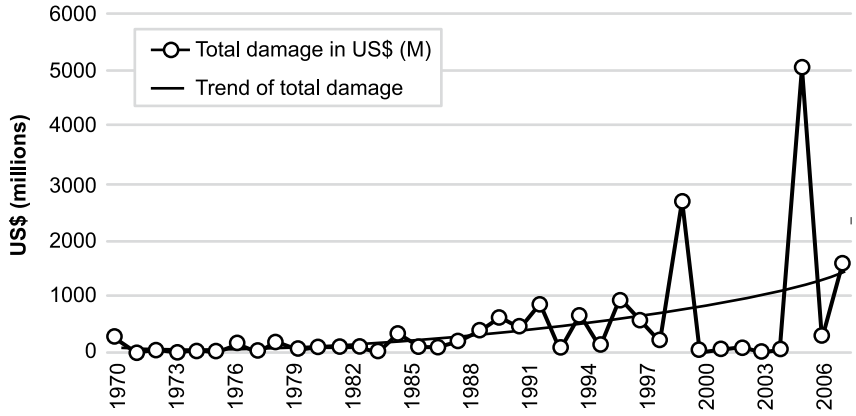

Figure 2.3: Total economic damages in US$(*106) due to natural disasters in South and Southeast Asia 1970-2006

(Source: EM-DAT, CRED, University of Louvain, Belgium)

resources are not officially recognized. Many poor and marginalised people are directly dependent on ecosystem services for their livelihood activities and are therefore particularly vulnerable to changes in environmental conditions and factors which may limit their access to such resources (Task Force on Climate Change, Vulnerable Communities and Adaptation, 2003). Capacity to cope therefore relates predominantly to differences in the level and distribution of poverty, access to natural, economic capital (credit, welfare) and social capital (networks, information, technology, relationships), the quality and effectiveness of governing institutions, as well as factors relating to health and globalization (e.g. Jäger et al., 2007, IPCC, 2001).

During the last few decades, a number of profound socio-economic and environmental changes have led to a large increase in disaster exposure and social vulnerability to hazards around the world (Munich Re, 2006). Many of the world's coastal areas have been experiencing rapidly growing concentrations of people and socio-economic activities (Bijlsma et al., 1996; WCC'93, 1994; Sachs et al., 2001; Small and Nicholls, 2003). The average population density in coastal areas is now twice as high as the global average (UNEP, 2005). Worldwide, more than 100 million people live within 1 meter of the sea level (Douglas and Peltier, 2002). Of the world's 33 mega-cities, 26 are located in developing countries and 21 in coastal areas (Klein et al., 2003). Figure 2.4 shows global coastal population and shore-line degradation.

Much of this development has been occurring in low-lying flood plains, river deltas and estuaries that are highly exposed to coastal hazards. In many cities, major rezoning of former industrial waterfront areas is being undertaken in flood-prone locations to accommodate the urgent requirement for housing units (e.g. Solecki and Leichenko, 2006).

Key socio-economic changes influencing hazard vulnerability in South and Southeast Asia include increasing population densities, population growth, migration to the coast, rapid and often poorly planned urbanisation (Bohle et al., 1994; ISDR, 2002; Klein et al., 2003; Pelling, 2003) and inappropriate development in high-risk areas for industry, shipping and transport, aquaculture, and tourism (Mitchell, 2003; Calgaro, 2005).

These processes cause large-scale land-use changes and transformations of hydrological systems in coastal areas, the destruction and degradation of coastal and marine ecosystems, and the loss of biodiversity and ecosystem goods and services (ISDR, 2002; Bohle et al. 1994; Mitchell, 2003; Adger et al., 2005), all of which are important determinants of vulnerability.

Many of the countries in South and Southeast Asia are developing countries (Table 2.2), with economies that consist mainly of agriculture, fishing and some manufacturing. Most of the countries in this

Figure 2.4: Coastal population and shoreline degradation
(UNEP 2002; data from Burke et al., 2001; Harrison and Pearce 2001)

region are of low and middle income,, but they are some of the fastest growing economies in the world (Haque 2003). The annual GDP growth rates during the period 1980-2005 have been more than 8% in East Asia and 6.5% in South Asia (ADB 2004).

Climate change has important implications for vulnerability to coastal hazards as it is expected to exacerbate the exposure of many coastal areas (Bijlsma et al., 1996; Nicholls, 2002; IPCC 2001). Sea-level rise is one of the most important manifestations of climate change. As global mean sea level is projected to rise by 0.09 to 0.88 m between 1990 and 2100 (IPCC, 2001), four major biogeophysical impacts are expected in coastal areas (Bijlsma et al., 1996): Inundation and displacement of wetlands and lowlands; shoreline erosion; exacerbation of storm flooding and damage; and an increase in the salinity of estuaries and threat to freshwater aquifers. These impacts will have a number of potential socioeconomic consequences, including the loss of economic, ecological, cultural, and subsistence values through loss of land, infrastructure, and coastal habitats; increased flood risk to people, land, and infrastructure, and the aforementioned values; and other impacts related to changes in water management, salinity, and biological activities (Klein and Nicholls, 1999).

Climate change is also likely to result in higher climate variability and changes in the frequency, intensity, and duration of extreme events (IPCC, 2001). In some areas of tropical Asia climate change is likely to increase tropical cyclone wind intensities and precipitation intensities, leading to increased coastal erosion, damage to buildings and infrastructure, and damage to coastal ecosystems such as coral reefs and mangroves (IPCC, 2001). Other projected changes include intensified droughts and floods associated with El Niño events and increased variability in the Asian summer monsoon precipitation (IPCC, 2001).

Climate change threatens to undermine many decades of development assistance, poverty reduction and disaster risk management efforts (Thomalla et al., 2006). In many developing and least developed countries extreme events occur so frequently that they tend to overwhelm the nation's coping capacity and hamper long-term progress because attention and resources desperately needed for poverty reduction and economic development are diverted to disaster relief and reconstruction (Thomalla et al., 2006). Developing countries are particularly affected by climate change because climate-sensitive

Table 2.2: Economy and development of South East Asian countries in 2004

Country	Income Classification	Human Development Index (Rank)	Human Poverty Index Rank	Official Development Assistance received (%GDP)*
Cambodia	Low income	131 (0.598)	24	8.7
Indonesia	Low income	107 (0.728)	62	0.9
Lao PDR	Low income	130 (0.601)	39	10.3
Malaysia	Middle income	63 (0.811)	93	1.1
Philippines	Middle income	90 (0.771)	72	0.6
Singapore	High income	25 (0.922)	102	n.a.
Thailand	Middle income	78 (0.781)	85	0.1
Vietnam	Low income	105 (0.733)	73	3.6

(Source: UNDP Human Development Report 2007/2008)

*: Data of 2005

sectors such as agriculture and fisheries tend to be particularly important economically and because these countries have limited human, institutional, and financial capacity to anticipate and respond to the effects of climate change (IPCC, 2001).

3. ANALYSING HUMAN VULNERABILITY TO ENVIRONMENTAL RISKS

3.1 Definition of vulnerability

Many definitions of vulnerability are currently in use by researchers working in different scientific disciplines and policymakers and practitioners of different policy and practice communities. VulnerabilityNet (www.vulnerabilitynet.org) provides a summary of some of the most frequently used definitions.

SEI defines vulnerability as the degree to which an exposure unit (e.g., social group, ecosystem) is susceptible to harm due to exposure to a perturbation or stress, and the ability (or lack thereof) of the exposure unit to cope, recover, or adapt(Kasperson, Kasperson et al. 2003). Vulnerability results from a combination of processes that shape the degrees of exposure to stresses, perturbations, and shocks; the sensitivity of people, places, and ecosystems to the stress or perturbation, including their capacity to anticipate and cope with the stress; and the resilience of the exposed people, places, and ecosystems, that is their ability to recover from the stress and to buffer themselves against, and adapt to, future stresses and perturbations. Vulnerability is a characteristic of all people, ecosystems, and regions confronting environmental or socio-economic stresses and, although the level of vulnerability varies widely, it is generally higher among poorer people (Kasperson, Kasperson et al. 2003).

3.2 Background and application

Vulnerability research has largely evolved from three academic communities: development and food security (Chambers, 1989; Watts and Bohle, 1993; Bohle et al., 1994; Ellis, 2000; FAO, 2001; Dilley and Boudreau, 2001), natural hazards (Wisner, 1993; Hillhorst and Bankoff, 2003; Pelling, 2003; Wis-

ner et al., 2004), and climate change (Burton, 1997; Handmer et al., 1999; Klein and Nicholls, 1999; Leichenko and O'Brien, 2002; IPCC, 2001; and Downing and Patwardhan, 2003).

In the social sciences, vulnerability usually concerns the socio-economic factors that determine people's ability to cope with stress or change (Pelling 2003). It is therefore a state of any individual, group, or community and is defined in terms of their ability to cope with and adapt to any external stress placed on their livelihoods and well-being (Adger and Kelly 1999). Vulnerability to food insecurity can be defined in terms of exposure, capacity and potentiality, where these three terms are shorthand, respectively, for the risks associated with: exposure to stress and crises; inadequate capacity to cope with stress; and the severe consequences of stress and the related risk of slow recovery (Watts and Bohle 1993). Here, capacity is the most important determinant of vulnerability and should be at the center of all policy-relevant analysis to vulnerability (Adger and Kelly 1999). In natural hazards, (Wisner, Blaikie et al. 2003) use terminology that places more emphasis on the social construction of vulnerability. According to the review by Manyena (2006), vulnerability in this context is described as social vulnerability and physical vulnerability, which represent the human dimension and non-human-involved ecological and environmental fragility, respectively. However, because of the slow onset and "hidden" nature of some hazards, some definitions, especially those that relate to vulnerability to climate change, do not define explicitly the dimensions exposure, sensitivity and resilience. For example, (Adger and Kelly 1999) describe vulnerability to climate change in terms of poverty, inequality and institutional adaptation, all of which are intrinsically linked to the political economy of markets and institutions. In the context of coastal hazards, vulnerability is defined as the degree of capability to cope with the consequences of climate change and sea-level rise (Klein and Nicholls 1999). This concept involves three aspects: the susceptibility of a coastal area to the physical and ecological changes imposed by sea-level rise; the potential impacts of these natural system changes on the socioeconomic system; and the capacity to cope with the impacts, including the possibilities to prevent or reduce impacts through adaptation measures (Nicholls and Hoozemans 2002).

Vulnerability analysis is an important extension of traditional risk analysis as it delineates the places, people, and ecosystems at risk from environmental and/or human induced variability and change, identifies the underlying causes of this vulnerability, and develops relevant recommendations for policy-makers on how to reduce vulnerability and adapt to change (Clark et al., 1998; Kasperson et al., 2005). Vulnerability analysis focuses on the perspectives and experiences of vulnerable and marginalised groups in understanding, in particular, the role of poverty, institutional weaknesses, globalisation, environmental factors and marginality, in creating vulnerability (e.g. Hewitt, 1997; Adger, 2003; Adger et al., 2005). By identifying people and places particularly at risk, capturing trends that may lead to unsustainable situations, and improving our understanding of the socially-differentiated nature of the impacts of change, opportunities and priorities for development interventions and early warning can be determined.

3.3 Conceptual framework for analysing vulnerability

Because of the multitude of definitions and applications, different conceptual frameworks for vulnerability assessment have been developed within largely separate scientific and practitioner communities (Thomalla et al., 2006). The multidisciplinary vulnerability framework jointly developed by researchers at SEI and Clark University (Turner et al., 2003) (Figure 3.1) illustrates the complexity and interactions involved in vulnerability analysis, drawing attention to the way in which multiple socio-political and physical processes, operating at different spatial and temporal scales, produce vulnerability within the coupled human-environment system. Fundamental to this conceptualisation of vulnerability is the distinction between the three major components of vulnerability (exposure, sensitivity and resilience), the factors that contribute to each dimension of vulnerability, and the linkages between them.

Exposure is defined as the degree to which an individual or group or ecosystem comes into contact with particular stressors or shocks (Khagram, Clark et al. 2003). In this framework it is the way

system components (e.g. individuals, households, social groups, communities, ecosystems) confront hazards. Exposure is not only determined by the vulnerability of system components, but also by the characteristics of the hazards, such as frequency, magnitude and duration.

Sensitivity is the degree to which an exposure unit is affected by exposure to any set of stresses (Khagram, Clark et al. 2003). Sensitivity is an indicator of the robustness of a system and relates to the capacity of the object unit in coping with the impacts of hazards. In this framework, sensitivity is defined as the complex interaction between human conditions (social/human capital, e.g. including population, entitlements, institutions, economic structures) and environmental conditions (natural capital or biophysical endowments). Sensitivity is shaped by interacting socio-political conditions and ecological conditions. It is dynamic because of continuous adjustments in policies and practices in anticipation of disturbances (Kasperson and Kasperson 2001) (Figure 3.2). Because this is a continuious process, it is very difficult to describe the sensitivity of a system. Only when the system is affected by a disturbance can sensitivity be characterised through the observed impacts and responses. Sensitivity, including structural properties, entitlements, and coping mechanisms, is influenced by factors operating at all levels. After the disturbance has occured, adaptation actions are likely to be undertaken to anticipate and cope with future shocks (Kasperson and Kasperson 2001; Turner, E.Kasperson et al. 2003).

The concept of resilience has been used to characterize a system's ability to bounce back to a reference state after a disturbance (Pimm, 1984). Other definitions emphasise the system's capacity to withstand or absorb recurrent external shocks and stresses and to maintain certain structures and functions despite disturbance (Adger, P.Hughes et al. 2005); Folke, 2006, Holling 1973, Harwell et al., 1977). (Walker, C.S.Holling et al. 2004) emphasize the system's capacity to reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedback

The Turner et al (2003) framework focuses on the analysis of vulnerability within a place-based coupled human–environment system. Rather than focusing on one particular perturbation or stress, the framework considers the effects of multiple stresses, that might arise from both the human and natural environments (Kasperson and Kasperson 2001) and influence the vulnerability of the coupled system through interacting processes that operate on different spatial and temporal scales. Thus the scale of analysis is an important element of vulnerability assessment. The term "place-based" describes a spatially- bound set of human and biophysical conditions in a coupled human– environment system. Some of the factors contributing to vulnerability are therefore specific to the particular location considered. At the same time, wider processes that originate outside it can affect vulnerability within the location.. These include both socio-economic processes, such as regional development patterns, trade and globalization, and environmental processes, such as up-stream/ down-stream relationships and global environmental change, in particular climate change.

3.4 Key advancements and challenges for vulnerability research

Recent research on the causal structures of current patterns of human vulnerability to environmental change (Kasperson and Kasperson, 2001; Turner et al., 2003; Pelling, 2003; Kasperson et al., 2005) has improved our understanding of how human agency and socio-political structures interact with physical systems in creating hazardous situations. Whilst earlier research tended to regard vulnerable people and communities as victims in the face of environmental and socio-economic risks, more recent work places increasing emphasis on the capacities of different affected groups to anticipate and cope with risks, and the capacities of institutions to build resilience and adapt to change (Bankoff, 2004).

There is also an increasing recognition that human vulnerability and livelihood security are closely linked to biodiversity and ecosystem resilience (Adger, 2000; Adger et al., 2005; Holling 2001; Folke et al, 2002; Millennium Ecosystem Assessment, 2005). The role of resilient ecosystems in underpinning resilient social systems and thereby decreasing vulnerability to natural hazards, is related to the capacity of ecosystems to buffer the impacts of extreme events. Healthy ecosystems are also able to

provide more options for communities to assist with livelihood recovery following a disaster. There is growing interest in the role of good governance and the social resilience dimension in reducing vulnerability to environmental risks and natural hazards. The need to establish linkages between poverty reduction, strategic environmental thinking, and disaster risk reduction to reduce vulnerability and build social-ecological resilience, is increasingly being recognised by scientists and practitioners alike.

The advances in theory and conceptual thinking in vulnerability research can be described as a transition from Environmental Impact Assessments in the late 1960s to Risk Assessment in the 1980s and 1990s, to Strategic Environmental Assessment in the 1990s then to Vulnerability Assessment in the 2000s (Kasperson, 2006 pers. comm.). This reflects a conceptual shift towards coupled social-ecological systems and an increasing emphasis on the dynamics of vulnerability and the complex interactions between different causes of vulnerability at different levels. Vulnerability, as well as sustainable livelihoods and resilience are increasingly considered to be central concepts for understanding change.

However, in spite of this progress, significant challenges remain in vulnerability research. Analysis remains largely static, with limited understanding of the spatial and temporal dynamics of vulnerability. Scale linkages and cross-scale dynamics between local manifestations of vulnerability and risk construction at larger levels, the effects of cumulative processes, and the likely trajectories of future change, are also poorly understood. The consideration of multiple stresses is recognised as important by many researchers but they are rarely captured in assessments. The linkages and interactions between human and ecological systems are not considered sufficiently, and the coping strategies and capacities of affected individuals, communities and institutions to adapt, are rarely assessed. The role of formal and informal institutions in facilitating or constraining adaptation to change is poorly understood and requires better definition and measurement.

3.5 Application of vulnerability analysis in policy and practice

Vulnerability analysis is now widely used in the work of many international organizations and research programmes concerned with poverty reduction and sustainable development, including the FAO, Humanitarian Aid Organizations such as the Red Cross/Red Crescent societies, UNDP, UNEP, World Bank and donor agencies.

However, conceptual advances in the approaches to reducing vulnerability to environmental changes and shocks have not yet been matched by advances in empirical research. The grounding of abstract theories and concepts and the translation of frameworks into operational methods and tools that produce policy-relevant insights remains weak. The translation of research into effective policy and practice is frequently hampered by a lack of appropriate methodologies and tools, and by research processes that don't reflect the needs of communities and decision-makers. The outputs of research are also frequently communicated in a language, and through channels, that are inappropriate for non-scientific audiences. Most outputs of vulnerability research are highly theoretical and conceptual and disseminated through peer-reviewed international scientific journals published in English.

Because vulnerability analyses are being undertaken in many different contexts and by scientists and practitioners working in different communities and sectors, a number of different definitions of vulnerability and conceptual frameworks for assessing vulnerability exist. The analysis in vulnerability assessments undertaken is highly context and place specific and very few rigorous comparative studies have been undertaken to date. Such studies are urgently needed to identify the underlying factors contributing to vulnerability and to determine typical patterns of vulnerability and policy response.

Recently, some progress has been made in improving such integrative analysis of vulnerability and human well-being in the context of environmental risks and change. The forthcoming UNEP Global Environment Outlook GEO-4 Chapter 7 "Vulnerability of Human-Environment Systems: Challenges and Opportunities" (Jäger et al., 2007) describes specific representative patterns of the interactions

between environmental change and human well-being. These so-called "Archetypes of Vulnerability" aim to illustrate the basic processes whereby vulnerability is produced and to enable policymakers to recognize their particular predicaments within a broader context, providing regional perspectives and important connections between regions and the global context and insights into possible solutions. The GEO-4 archetype approach is inspired by earlier work at PIK for the German Advisory Council on Global Change on the "Syndromes of Global Change" which describes non-sustainable patterns of human-environment interaction, and analyses the dynamics behind them (Lüdeke et al., 2004; Lüdeke and Petschel-Held, 1997; Schellnhuber, 1998; Schellnhuber et al., 1997, 2002), but is broader, as it includes opportunities offered by the environment to reduce vulnerability and improve human well-being (Jäger et al., 2007; Wonink et al., 2005; Thomalla et al., 2006).

However, these analyses are largely qualitative and the archetypes were identified through a consultative process that included not only the latest research findings on environmental and socio-economic changes, but also a large degree of "expert judgement" as well as regional priorities put forward by national governments. They also do not represent a complete overview of all possible patterns of vulnerability, but are merely intended to provide a good basis for identifying challenges and exploring opportunities for reducing vulnerability and protecting the environment (Jäger et al., 2007).

There is an urgent need to develop methodologies that formalise research approaches in order to more adequately describe and quantify representative or typical patterns of vulnerability of human-environment systems to multiple stresses that arise from complex and interacting environmental and socio-economic changes and to produce policy-relevant findings that better inform vulnerability reduction and adaptation to climate change (Füssel, 2006; Füssel and Klein, 2006, Hinkel and Klein, 2006a,b; Ionescu et al., 2006). Such formalization would support accurate communication within and between different academic communities and practitioners, and eliminate misunderstandings which result from the use of ambiguous terminology.

4. METHODOLOGY FOR UNDERTAKING A META-ANALYSIS

4.1 Background and purpose of a meta-analysis

The results of a single study can be influenced by characteristics of the study setting, the sampled population, timing, locations and the subjective bias of the researchers. Causal factors can only be unearthed by a synthesis of multiple studies . Some general trends and underlying principles can only be deduced across a large body of case studies or empirical studies. Meta-analysis is one analytical approach with which to gain such additional scientific insights from previous investigations. It therefore plays an important role in the dissemination of knowledge and in determining the direction of subsequent research, policies and practice (Sandelowski, Docherty et al. 1997).

Beecher (1955) undertook the earliest example of a meta-analysis and Glass (1976) coined the term "meta-analysis" to refer to a philosophy ,rather than a statistical technique. Glass argued that a review of literature should be as systematic as primary research and that one should interpret the results of individual studies in the context of distributions of findings, partially determined by study characteristics and partially randomly. However, the meta-analysis technique began as a statistical procedure for combining and comparing research findings from different studies, focusing on similar phenomena (Nijkamp and Pepping 1997-98), and a variety of meta-analytical methods have been developed (Nijkamp 1999) over the past few decades.

In some studies, "meta-analysis", "meta-synthesis", "synthesis review", and some other terms, are not distinguished clearly, but there are uses of the technique in various fields of research. While some researchers refer to the term "meta-analysis" as the quantitative integration and analysis of the findings from all empirical studies relevant to an issue and amenable to quantitative aggregation (Glass 1976), most treat the terms "literature review", "synthesis review", "synthesis analysis" and "meta-analysis" as equivalent. Here we take the definition of "meta-analysis", as "…an analytical framework

for comparative research that aims to draw inferences on common issues with different but allied empirical backgrounds" (Matarazzo and Nijkamp 1997).

Meta-analysis has now become a widely accepted research tool, encompassing a range of procedures used in a variety of disciplines, such as psychology, labour economics, environmental science, and transportation science (Gaarder 2002; Yu 2002; Greenaway, Milne et al. 2004; Travisi, Florax et al. 2004). There are however few uses of this methodology in the field of natural hazard research. For example, (Harremoes, Gee et al. 2001) studied 14 "man-made" disaster cases and investigated the reasons behind ineffective early warnings. The study demonstrated that in most cases information warning of the potential harm was available at an early stage, but that due to the complexity of the situation, lack of awareness, and the politically high stakes of the decision-making process, many warnings were not implemented effectively or not implemented at all.

The purpose of this kind of meta-analysis is to combine findings from separate but largely similar studies. According to some researchers, such studies may be suitable for the application of a variety of analysis techniques (common literature review, formal statistical approaches, etc.) for combining, comparing, selecting or seeking out common elements, relevant results, cumulative properties etc. from a broad set of individual cases (Matarazzo and Nijkamp 1997).

4.2 The process of undertaking a meta-analysis

Meta-analysis involves a critical examination of multiple accounts of phenomena to review similarities and differences among them (Nijkamp and Pepping 1997-98). This analysis requires the establishment of an analytic strategy and coding system to categorize data and to interpret findings in relation to predefined research questions. According to (K.Glasmeier and Farrigan 2005) the synthesis process on qualitative research comprises seven steps:

- Formulation of research questions:
- Tentative questions are formulated, a theoretical framework is chosen, and workable definitions of key concepts are generated.
- Selection and appraisal of primary research (development of a literature search strategy):
- The inclusion and exclusion criteria are identified, the appropriate data sources are specified, and the data screening and appraisal procedure is developed. The latter includes the development of a filing and coding system for the collected studies, as a basis of the analysis and synthesis.
- Analysis and synthesis of the theories (meta-theory):
- Major paradigms in different studies and schools of thought represented in the theoretical and emerging theory of reports (K.Glasmeier and Farrigan 2005) are identified and significant assumptions underlying specific theories are uncovered.
- Identification of an analytic strategy (meta-analysis):
- The data is collected, inter-coder consensus is obtained, and findings are discussed and interpreted.
- Analysis of the methods in collected cases (meta-method):
- The methodological characteristics of selected reports are analysed and the way in which these characteristics influence the research findings is discussed.
- Synthesis of the outputs of the above processes (meta-synthesis):
- The various discrete contributions to the questions are critically interpreted, drawing out common characteristics across the cases, and searching for alternative explanations for paradoxes and contradictions within them.
- Presentation and dissemination of the findings.

The process of meta-analysis is not a linear process. 3), 4) and 5) are parallel steps that focus on different aspects of theories, contents and methodologies. Also, the various steps overlap and are circular. The development of the coding system continues throughout all stages, in order to substantiate the process and make sure that all important information is included. In this way, the coding system can be modified, revised and supplemented according to concrete cases. Using this kind of feedback

loop also works well with the vulnerability assessment framework of Turner et al (2001), which also reflects the feedback circulation of the impacts and causes of the vulnerability.

(Matarazzo and Nijkamp 1997) present the meta-study as six different "levels", each of which assumes a particular importance from a methodological point of view: named real-world level, study level, pre-meta-analysis level, study selection level, meta-analysis level and implementation level:

- At the real-world level, the field of study is identified, and the problem issues are clarified.
- At the study-level the case studies are collected. This involves the formulation of theoretical hypotheses regarding the phenomenon studied. A pre-selected model is applied to simplify the representation of reality (Matarazzo and Nijkamp 1997), select suitable techniques and collect the data.
- At the pre-meta-analysis level the objectives of the synthesis to be carried out and the specific problems to be solved are explicitly defined and the dimensions in terms of time and space are established.
- At the study selection level the process for the selection and the coding of individual cases is defined.
- At the meta-analysis level the comparative analysis and synthesis of cases and the evaluation of the consistency of the results is undertaken.
- At the implementation level there is a post-meta-analysis phase, which means a "feed-back" or application of the conclusions to the real world. In this phase, not only the explicit results are considered, but also the effects of the experience acquired and the implicit indications. This means that the meta-study research is an integrated process and a second-order analysis that seeks not only to synthesize the results of prior works, but also to reflect upon the processes within that research (Glasmeier and Farrigan 2005; K.Glasmeier and Farrigan 2005).

The relationships between these different levels and steps in a meta-analysis are shown in Figure 4.1.

The different levels described in Figure 4.1. indicate the corresponding steps of a meta-analysis: 1) formulating the research questions, 2) choosing an appropriate conceptual framework, 3) developing a literature search strategy, 4) collecting case studies, 5) coding information from individual case studies, 5) formulating and describing the object under investigation, and 6) synthesizing the data collected from individual case studies.

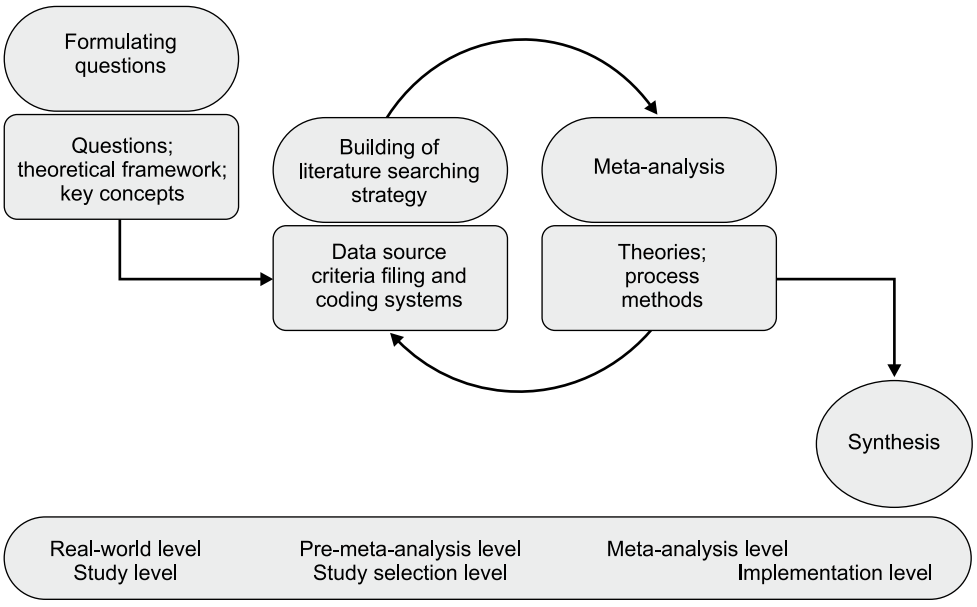

Figure 4. 1 The different levels and corresponding steps of a meta-analysis

4.2.1. Formulating the research questions

In line with the process identified in Section 4.2., the first step in undertaking the analysis is to identify the problem to be investigated and to formulate the research questions guiding the analysis. In order to conduct a meta-analysis it is necessary to define a clear outcome of vulnerability as a basis of the analysis and to narrow down the large volume of research that has been undertaken in this area to-date. In this study, we define the outcome of vulnerability as a loss of human life resulting from coastal hazard related impacts.

The following research questions were identified to guide the analysis:

- **How can the current knowledge on coastal hazard vulnerability be characterized?**
  This question relates to the production and ownership of knowledge and includes questions such as what types of assessments are undertaken, and who undertakes them.
- **What methods are used to assess vulnerability?**
  How is vulnerability conceptualized and defined? What methods are used in vulnerability assessment? At what spatial and temporal scales is the assessment undertaken? Which geographical locations are the focus? What indicators are used to describe vulnerability?
- **What is the current state of knowledge?**
  How does vulnerability manifest itself in particular locations and situations? Which locations, individuals and social groups are particularly vulnerable and why? What are the key factors contributing to their vulnerability? How do multiple factors interact? What processes occur at what scales and what is their relative importance?
- **To what extent is vulnerability specific to location, situation, ecosystem, or sector?**
  Is there a systematic causal structure of vulnerability? Are there common elements or typical patterns of vulnerability and policy response that can be characterized, formalized and transferred to similar situations in other regions?
- **What are the key lessons for policy to reduce hazard vulnerability?**
  Does a systematic synthesis of existing knowledge reveal new insights and lessons for reducing vulnerability and building resilience to coastal hazards? What are the disparities between research, policy and practice on disaster risk reduction? What new knowledge is needed to support more effective decision-making?

4.2.2. Choosing a conceptual framework to guide the analysis

Because of the multitude of definitions and applications of vulnerability, different conceptual frameworks for vulnerability assessment have been developed within largely separate scientific and practitioner communities (Adger, 2006, Eakin and Luers, 2006; Thomalla et al., 2006). The choice of conceptual framework is important because it indicates the connotations, scales, and philosophy of the concepts and relative terms and definitions used. In this analysis the framework needs to reflect the complex interactions occurring in the coupled social environmental system. In addition, the choice of conceptual framework affects the process of the meta-analysis in terms of the organisation and categorization of information and the presentation of the results.

We chose the Turner et al. (2003) (Figure 4.2) framework as the conceptual basis for the meta-analysis. This multidisciplinary vulnerability framework illustrates the complexity and interactions involved in vulnerability analysis, drawing attention to how multiple socio-political and physical processes, operating at different spatial and temporal scales, produce vulnerability within the coupled human-environment system. Fundamental to this conceptualisation of vulnerability is the distinction between the three major components of vulnerability (exposure, sensitivity and resilience), the factors that contribute to each dimension of vulnerability, and the linkages between them.

Exposure is defined as the degree to which an individual, or group, or ecosystem, comes into contact with particular stressors or shocks (Khagram et al. 2003). In this framework it is the way system components (e.g. individuals, households, social groups, communities, ecosystems) confront

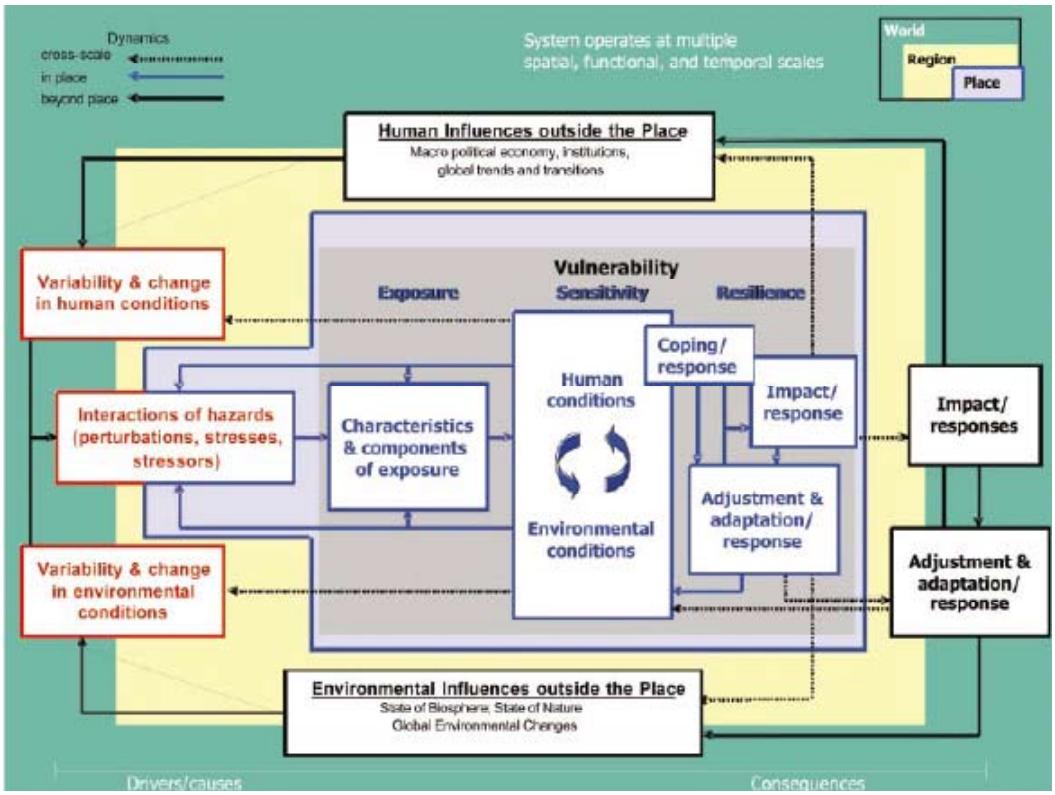

Figure 4. 2 The Turner et al. (2003) framework for vulnerability assessment

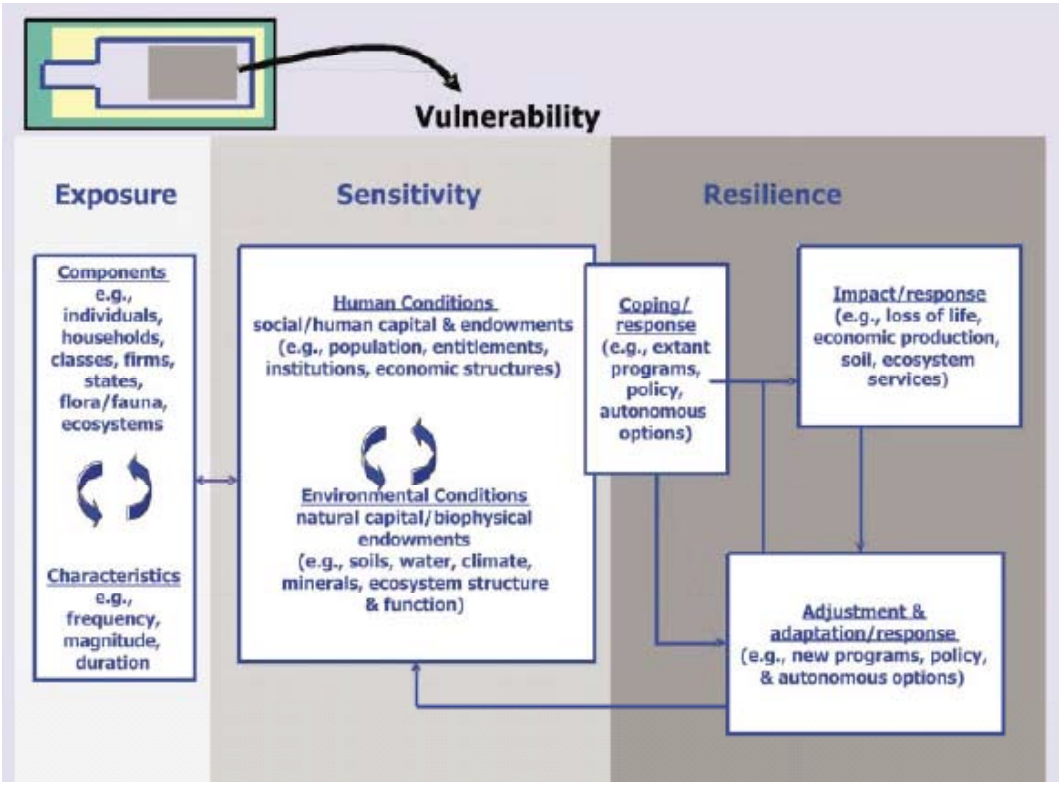

Figure 4. 3 Details of the exposure, sensitivity and resilience components of the Turner et al. (2003) vulnerability framework

hazards. Exposure is not only determined by the vulnerability of system components, but also by the characteristics of the hazards, such as frequency, magnitude and duration.

Sensitivity is the degree to which an exposure unit is affected by exposure to any set of stresses (Khagram et al. 2003). Sensitivity is an indicator of the robustness of a system and represents the capacity of the object unit to cope with the impacts of hazards. In this framework, sensitivity is the complex interaction between human conditions (social/human capital, e.g. including population, entitlements, institutions, economic structures) and environmental conditions (natural capital or biophysical endowments). Sensitivity is shaped by interacting socio-political conditions and ecological conditions. It is dynamic as a result of continuous adjustments in policies and practices, in anticipation of disturbances (Kasperson and Kasperson 2001) (Figure 4.3). Because this process is continuous, it is very difficult to describe the sensitivity of a system. Only when the system is affected by a disturbance can sensitivity be characterised through the observed impacts and responses. Sensitivity, including structural properties, entitlements, and coping mechanisms, is influenced by factors operating at all scales. After the disturbance has happened, adaptation is likely to occur to anticipate and accommodate future shocks (Kasperson and Kasperson 2001; Turner et al. 2003).

The concept of resilience has been used to characterize a system's ability to bounce back to a reference state after a disturbance (Pimm, 1984). Other definitions emphasise the system's capacity to withstand or absorb recurrent external shocks and stresses and to maintain certain structures and functions despite disturbance (Adger et al. 2005); Folke, 2006, Holling 1973, Harwell et al., 1977). (Walker et al. 2004) emphasize the system's capacity to reorganize while undergoing change, so as to retain essentially the same function, structure, identity, and feedbacks.

The Turner at al (2003) framework focuses on the analysis of vulnerability within a place-based coupled human–environment system. Rather than focusing on one particular perturbation or stress, the framework considers the effects of multiple stresses, that might arise from both the human and natural environments (Kasperson and Kasperson 2001) and influence the vulnerability of the coupled system through interacting processes that operate at different spatial and temporal scales. Thus the scale of analysis is an important element of vulnerability assessment. The term "place-based" describes a spatially bounded set of human and biophysical conditions in a coupled human– environment system. Some of the factors contributing to vulnerability are therefore specific to the particular location considered. At the same time, wider processes that originate outside the location can affect vulnerability within it. These include both socio-economic processes, such as regional development patterns, trade and globalization, and environmental processes, such as up-stream/ down-stream relationships and global environmental change, in particular climate change.

4.2.3. Literature search and selection of literature to be analysed

The third step is the development of a search strategy for the identification and collection of literature that forms the basis of analysis and synthesis.

In this project we included peer-reviewed scientific articles including place-based vulnerability case studies and theoretical and conceptual discussion papers, as well as so-called "gray literature" that includes reports published by humanitarian and civil society organizations concerned with disaster risk reduction.

The literature search was undertaken in two steps:

- Scoping of the literature:

  We developed search filters (combinations of search terms) to identify articles relevant to the objectives of the review and undertook searches for existing reviews and primary studies, relevant to the objectives of the review.
- Review of questions:

  The aim of reviewing questions was to determine the true topical similarity of studies. This entailed the comparison of studies on broad surface parameters, including stated research purposes, research questions asked, and the outputs produced (Sandelowski, Docherty et al. 1997).

To obtain a first overview of the types of studies undertaken on coastal disasters, we initially searched papers using the combined keywords “floods”, “coastal disasters”, and “loss of life” in the literature database http://scholar.google.com. We then selected at random several cases from the search results. We found both qualitative (e.g. (Zong and Chen 1999; Adger, Hughes et al. 2005) and quantitative (e.g. (Haque 2003; Jonkman 2005) studies, which made both the meta-analysis of quantitative data and the meta-synthesis of qualitative studies necessary.

In order to minimise the likelihood of excluding important information or views (Sherwood 1999), a thorough and comprehensive literature search was undertaken. This required an appropriate and efficient search strategy.

According to (Berz, Kron et al. 2001; Jonkman 2005), several different types of floods have been defined: coastal floods (or storm surges), flash floods, river floods, drainage floods, tsunamis and tidal waves.

Because we focused on coastal disasters, and the concept of flood involves too broad a scale, we chose to limit our search to coastal floods (storm surges), tsunamis, tidal waves, hurricanes and marine-related infectious diseases (Adger, Hughes et al. 2005).

Geographically, we limited our search to Southeast Asia, which includes ASEAN (Brunei, Cambodia, Laos, Malaysia, Burma, Philippines, Singapore, Thailand and Vietnam) as well as Bangladesh, India, and Indonesia.

Considering availability and authenticity, the following electronic databases were used as sources:

JSTOR	www.jstor.org
Sciencedirect	www.sciencedirect.com
Springerlink	www.springerlink.com
Synergy	www.blackwell-synergy.com
Google	http://scholar.google.com
Emerald	www.emeraldinsight.com

For those databases that allowed searches in several languages, the search was limited to documents in English. The time period examined was from 1970 to March 2006.

The selected keywords are shown in Table 4.1.

Whilst it would seem necessary for the synthesis to include as many studies as possible, (Sandelowski, Docherty et al. 1997) argued that in any kind of qualitative research, overly large sample sizes tended to impede deep analysis and threaten the interpretive validity of findings. The field of Sandelowski’s study was health and nursing, in which there were relatively fewer uncertainties and the topics mainly focused on the effectiveness of certain remedies, the environment around the illness and the impacts of some external factors on the therapies. For more complex issues that involve many uncertainties, more studies are required in order to ensure a complete and comprehensive analysis.

For the process of sampling, the method of Suri (1999) was applied. According to this method, the search for additional literature can be terminated once the stage of data-redundancy is reached, where every additional case included in the synthesis is likely to tell the same story, rather than provide a new perspective. Preliminary content analysis was used to determine redundancy.

4.2.4. Coding of case study information

The fourth step is the development of a methodology for documenting and coding of information to be extracted from the large amount of reviewed literature selected in step 3. In order to avoid limiting the approach, or excluding relevant literature, we did not apply a pre-defined coding system, but developed a new system which was flexible enough to be updated throughout the process as new information became available.

Table 4. 1 Keywords used to identify relevant literature

steps	keywords	notes
1	Coastal disasters	Type I: Type of hazard
2	Coastal Floods	
3	Hurricanes	
4	Tsunamis	
5	Storm surges	
6	Tidal waves	
7	Marine-related infectious diseases	
8	Combinations of 1-7	
9	South-east Asia	Type II: Region
10	South Asia	
11	East Asia	
12	Asia	
13	Islands	
14	Any of the countries' name	
15	Loss of life	Type 3: Aspects of hazard vulnerability
16	Deaths (death rate)	
17	Mortality (mortality rate)	
18	diseases	
19	health	
20	social	
21	impacts	
22	Vulnerability (vulnerable)	
23	Causes	
24	Consequences	
25	development	
26	23+15(or 16 or 17)	
27	23+18	
28	23+22	
29	20+21	
30	20+22	
31	20+24	
32	20+25	

Coding needs to be undertaken in a way that allows both quantitative and qualitative analysis of the information recorded. Quantitative analysis includes statistical analysis on the numbers and frequencies of certain kinds of information, such as how many times a particular cause of vulnerability is mentioned or how many case studies were conducted in a particular country. Qualitative analysis is aimed at gaining an improved understanding of the key causes of vulnerability, their complex interactions, and key lessons for vulnerability reduction. Synthesis analysis was applied to draw out general or transferable insights and conclusions from the literature.

The potential factors contributing to vulnerability mapped out in the conceptual framework relate to many different aspects of the coupled social environment system. At the beginning of the coding process, information was organised in predefined categories according to the conceptual framework. As the analysis progressed, an increasing amount of information was extracted from the reviewed literature and additional insights were obtained. These new insights were then phrased as questions and added to the coding system, forming new categories or sub-categories. The review of the literature and the development of the coding system was a circular process as new insights on the causes of vulnerability emerged throughout the analysis.

The coding system developed for this consisted of the following eight sections: 1) basic information, 2) type and scale of assessment, 3) methodology and data, 4) definition of vulnerability, 5) defini-

tion of the vulnerability complex, 6) causes of vulnerability, 7) vulnerability indicators, and 8) recommendations for policy and practice (Table 4.1.). Basic information included the title of the document, the name(s) of the author(s), publication details, type of publication and the disciplinary affiliation and epistemology of the author(s). Sections 5) (causes of vulnerability) and 7) (recommendations for policy and practice) were the main analytical sections, which contained detailed information on the identified causes of vulnerability and the recommendations put forward for reducing vulnerability. Further analysis of the interactions between these causes and recommendations was undertaken on the basis of these two sections. The other sections were aimed at characterising the research concerned with coastal hazards in South and Southeast Asia. These questions addressed aspects of the reviewed documents, such as the type of study, study location, time frame of the analysis, and the use of theories, concepts and methodologies. A simplified version of the coding system is shown in Table 4.1. (for the complete version refer to Annex 1).

In order to simplify the analysis and to allow statistical analysis to be undertaken, all questions were designed as 'yes' or 'no' questions. Because of the multi-disciplinary nature of this area of research, the definitions, understandings, and expressions of the concept of vulnerability (and related concepts, such as resilience) varied considerably. Therefore it was considered best to analyse the selected literature manually, rather than using automated methods such as the counting of key words. Another reason for the choice of non-automated methods was that frequently causes of vulnerability and relationships between them were not expressed explicitly, but rather indirectly through descriptive narratives. Finally, two rounds of review were undertaken to ensure that no information was missed or recorded in duplicate.

Table 4. 2 A simplified version of the main sections of the coding sheet

Meta-analysis of case studies on vulnerability to coastal hazards in Southeast Asia
Section 1 - Basic Information
Title of article
Authors
Publication details
Type of publication
Discipline of authors
Section 2 - Type and Scale of Assessment
Which framework is used to analyse vulnerability?
What is the scale of analysis?
In which country is the case study undertaken?
In which locations or regions is the case study undertaken?
During which time (period) is the case study undertaken?
Section 3 - Methodology and Data
What is the purpose of the study?
Which methodology is used in the case study?
What kind of data (socio-economic/environmental) is presented, at what scale?
What categories are used to aggregate data (e.g. gender, age, ethnicity, society-economic groups, rural-urban, geographic regions)?
Is a figure for the number of deaths and affected people provided?
Section 4 - Definition of Vulnerability
Is a definition of vulnerability provided?

Section 5 - Defining the Vulnerability Complex
Which primary hazards are identified?
Which secondary/associated hazards are identified? (e.g. environmental stresses, diseases, conflicts, food insecurity)?
If multiple hazards exist, are they ranked by importance?
Is there a discussion on the links or interactions between the different hazards?
Are particular vulnerable individuals/groups identified?
Are vulnerable locations (e.g. urban squatter settlements, floodplains, or parts of the country) identified?
Section 6 - Causes of Vulnerability
What are the main causes of vulnerability mentioned?
What are the areas/locations most affected?
Who is most exposed to impacts (e.g. age, gender, social status, ethnicity, livelihood)?
What sectors are most affected (e.g. infrastructure, agriculture, aquaculture, manufacturing, services, tourism)?
Are certain social groups more able to recover from environmental shocks and natural hazards identified?
How do entitlements determine vulnerability/resilience?
Section 7 - Vulnerability Indicators
Are specific vulnerability indicators presented and at what scale?
Section 8 - Recommendations for policy and management
Are recommendations for reducing vulnerability presented?
What are the measures suggested to reduce hazard vulnerability?

5 ANALYSIS AND RESULTS

5.1. Overview and characterisation of the selected literature

The literature search resulted in a total of 128 eligible papers. Of these, 120 were scientific articles published in academic journals and 8 were journal editorials or communications. This body of literature was statistically analysed to reveal information on the types of study undertaken, the spatial scale of analysis, country or regional focus, hazard types, disaster management phase, conceptual approach, and research methodology.

5.1.1. The types of studies undertaken

The literature can be categorised as follows:

- Conceptual papers: These tended to present a conceptual framework or theoretical analysis of disasters (e.g. (Green 2004)) or a theoretical interpretation of a certain phenomenon (e.g.(Cutter 1995; Manuta and Lebel 2004)).
- Review and general discussion papers: These tended to provide a historical analysis or wider analysis (e.g. (E.Drabek and A.McEntire 2003; P.Chittibabu, S.K.Dube et al. 2004)). Papers that discussed protocols and guidelines also belong to this group.
- Case studies: These tended to focus on a particular disaster event in a particular region and tended to consider a particular aspect of the disaster, such as early warning (e.g. (Kelman 2006)), disaster impacts (e.g. (Maramai and Tinti 1997)), or post-disaster rehabilitation (e.g. (Gupta and Sharma 2006)).
- Methodological papers: These tended to develop methodologies for assessing or simulating disasters and scenarios (e.g. (Arnell, Livermore et al. 2004)).

Because South & Southeast Asia are particularly vulnerable to coastal hazards and experience severe and frequent losses through such events, one would expect a plethora of case studies to be conducted in this region. Surprisingly, however, the majority (70) of the 128 papers were review and general discussion papers. There were 46 case studies, 12 conceptual and 8 methodological papers (Figure 5.1).

Most of the review papers focused on more general institutional policies or integrated management approaches for water-related hazards. A relatively small number were concerned with concrete aspects of disaster risk reduction or specific practical implementation measures.

Table 5. 1 The scales of analysis in vulnerability assessment

scale	description	example
community	Several small unions that are intimate and held together by shared interests and values, also by geographical proximity (different concepts of community exist within sociology, geography, politics, etc. (e.g. (Ley 1977; Walmsley 2000)). Since the geographical contiguity is the most common characteristic, the description of (Kent, Gill et al. 1997) is adopted.)	Rural: one or several close villages; Urban: one or several blocks and neighbourhoods
local	One or several districts that are geographically close, consist of one or several administrative counties or provinces and face the same hazards (Reference?).	Orissa, India; Metropolitan Manila, Philippines
national	A whole country.	India, Philippines, etc.
multi-national	A collection of several countries. They usually share some common characteristics, such as geographical figures. Also they are usually geographically close.	Southeast Asia; countries around the Bay of Bengal
global	The entire world. Does not refer to every country in the world, but describes global characteristics and processes.	

5.1.2. Spatial scale of analysis

The vulnerability framework of (Turner, E.Kasperson et al. 2003) is an explicit place-based framework. Regardless of the spatial dimension considered in a particular case study, the coupled human-environment system constitutes the focus of analysis. The term "place-based" implies a spatially continuous distinctive "ensemble" of human and biophysical conditions or coupled human-environment system (Turner, E.Kasperson et al. 2003). The concept of place allows the analysis of processes occurring at the local level through the use of bottom-up methodologies (such as vulnerability assessment at the community level or at relatively small scales) whilst also considering the interactions of processes operating on a larger scale and their effects at the local level. Changes manifested in particular locations are frequently connected to wider processes such as globalization and macro political processes as well as changes in the global biosphere.

In this synthesis, we applied the Turner et al. (2003) framework as a conceptual guide to analysis and employed the concepts of scale and place to analyze the factors of social vulnerability to coastal hazards at all scales, on a place basis. We considered four scales of analysis: community, local, national, multi-national and global (Table 5.1).

In the selected body of literature, 93 papers presented research undertaken at scales greater than the national level (global, multi-national and regional), 32 papers presented analysis at the local level, such as a particular coastal area, an impacted city, or a vulnerable district, and 3 papers presented work at the community level (Figure 5.2).

5.1.3. Hazard focus

Corresponding with the large number of review papers and the large scale of the investigations, most of the papers discussed disaster risk in the context of multiple hazards, including floods, tsunamis, cyclones, climate change impacts, and other hazards, with the aim of establishing common guidelines for integrated disaster risk reduction strategies (Figure 5.3).

Even though South & Southeast Asia have long been suffering, in particular, from the impacts of sudden shocks such as tsunamis and tropical cyclones, the second largest proportion of the literature (52 papers or 41%) focused on the slow-onset effects of climate change and sea level rise (Figure 5.3), covering all aspects of climate change- related impacts and vulnerabilities, including the particular

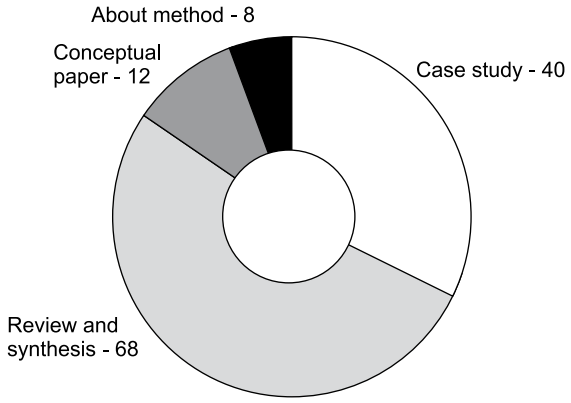

Figure 5. 1 Selected literature by type of study

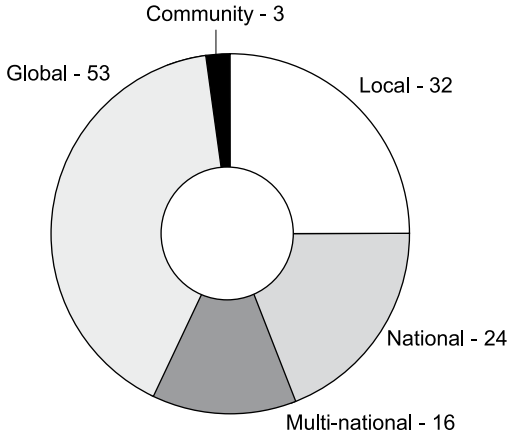

Figure 5. 2 Selected literature by scale of analysis

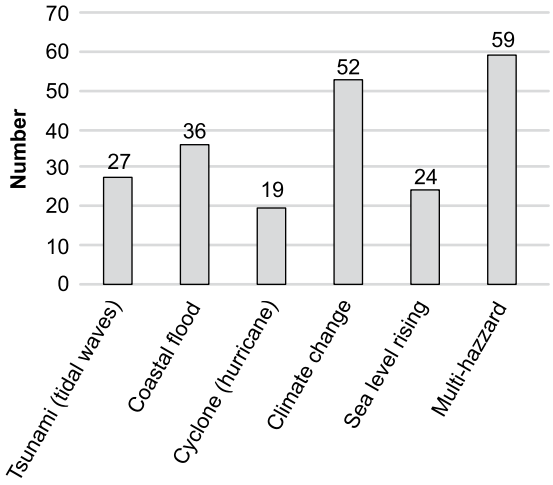

Figure 5. 3 Selected literature by hazard type

vulnerability of coastal regions and certain social groups, the impacts on livelihoods, and the relationship between sea-level rise and land use.

The reason for this emphasis on climate change might be related to two factors: 1) a large proportion of the global and multi-national research assumes that climate change is a hazard that has a close relationship with the evolution of social vulnerability and people's livelihoods. 2) It is assumed, though not clearly established, that climate change might in some regions influence natural processes and conditions in the oceans and the atmosphere, such as El Nino and wind storms that are likely to increase the risk of hydrometeorological hazards in the coastal zone (e.g. IPCC, 2001). 24 papers or 19% of the selected literature focused on sea-level rise, which is one of the consequences of climate change and one of the most important drivers of coastal floods and water resource management challenges in coastal areas. Coastal floods are complex hazards that comprise freshwater as well as marine floods. They can be a result of inland floods, or of other hazards such as wind storms and tidal waves, or of a combination of several or all of these. This complexity might explain why the literature on coastal floods accounted for the largest proportion of the papers pertaining to one particular hazard.

5.1.4. Geographical focus

As shown in Figure 6.4, the largest number of papers (53 or 41%) considered coastal hazards at the global scale. The second largest number of papers (26 or 20%) considered the whole region of South & Southeast Asia, and 5 papers or 4% the Pacific Small Islands. In total, they account for 41% (31/75) of papers with an explicit regional focus.

Of the papers that focused on a particular country, most dealt with Bangladesh, India, and Vietnam. In addition, there were nearly 30 papers (less than 25%) covering seven other countries: Indonesia, Philippines, Thailand, Sri Lanka, Vietnam, Malaysia and the Maldives. In total, 38 cases studies focused on 9 countries and multi-country regions (Figure 5.5).

5.1.5. Emphasis within the disaster risk reduction cycle

Figure 5.6 indicates that the volume of research emphasis is not distributed evenly, rather, more attention is paid to certain phases of the disaster risk reduction cycle. More than half of the documents (73) focus on the integrated management of water-related hazards, including institutional policies and general management guidelines, while a relatively small number (38) focus on more concrete and detailed implementation measures. 42 documents provide a disaster impact analysis, 27 discuss the development of an early warning system, and one document discusses responses during the time of the disaster itself. The number of papers on loss assessment is 8. The small number of documents focusing on losses might be related to the challenge of measuring accurately the loss of social capital and long-term and cumulative impacts, in current assessment methods.

5.1.6. Choice of research methodology

A large proportion (73 papers, including overlaps with other emphases, Figure 5.6) of the selected literature focuses on integrated disaster risk management issues. In these publications, narrative and general discussion methods prevail. Such methods are used in 108 (84% of all) papers. Statistical analysis is used in 27 (21% of all) papers, field study in 38 (30% of all) papers and simulation in 6 (5% of all) (Figure 5.7).

5.1.7. Disciplinary affiliation of the journals and authors

Looking at the disciplinary affiliation of the journals in which the selected papers are published, it appears that, with the recognition of increasing hazard vulnerability, and the increasing understanding of the causes of vulnerability, two distinct approaches can be identified:

Some documents focus predominantly on the hazard itself. A large proportion of the hazard-related literature (73 papers, more than 57%) is published in a limited number of journals that have an exclusive focus on natural hazards. These include the journals "Disaster Prevention and Management" (34

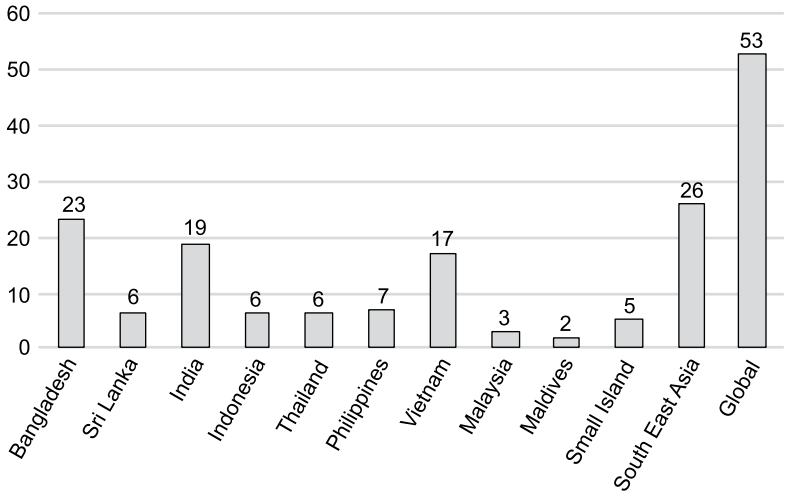

Figure 5. 4 Selected literature by geographical focus

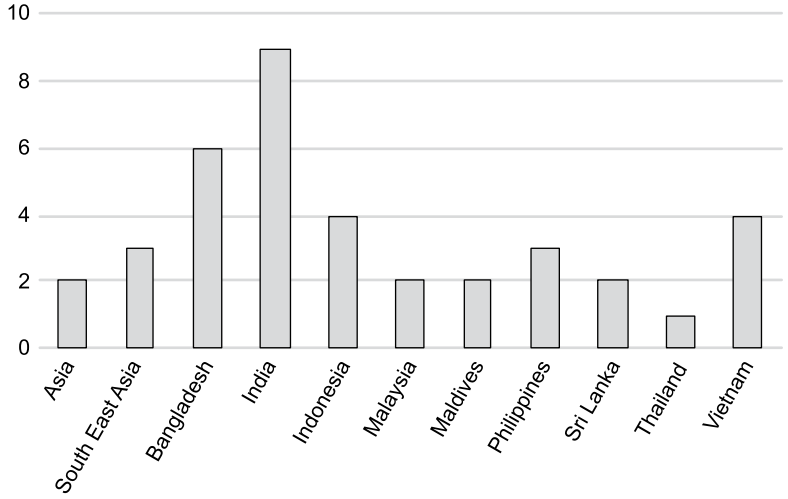

Figure 5. 5 Geographical focus of case studies

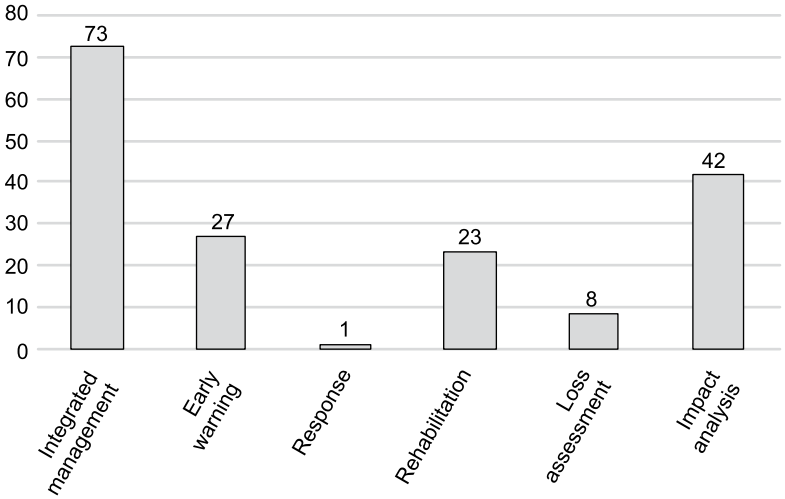

Figure 5. 6 Emphasis within the disaster risk reduction cycle

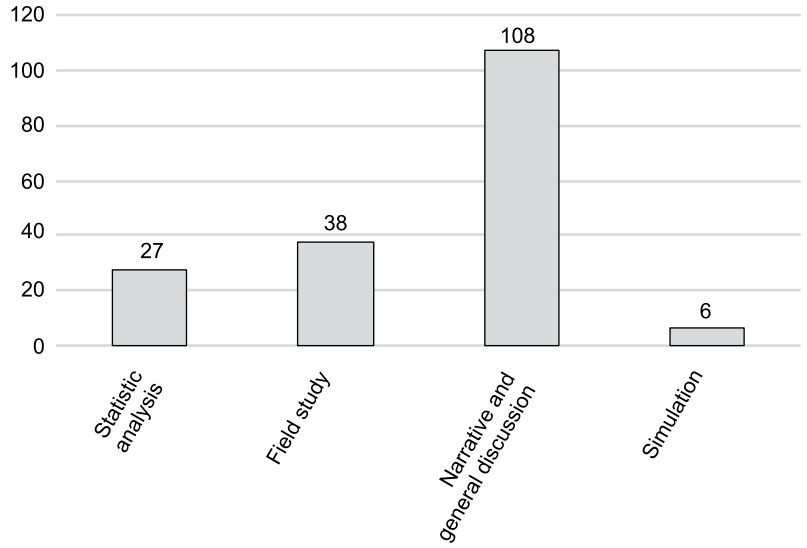

Figure 5. 7 Choice of research methodology

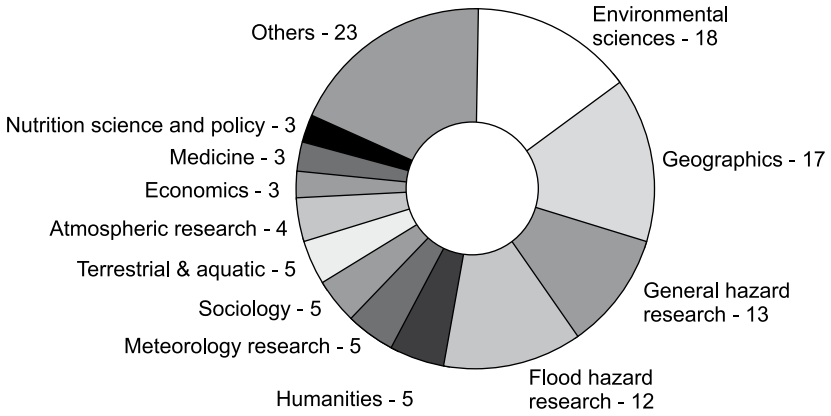

Figure 5. 8 Disciplinary affiliation of authors

papers or 27% of all selected publications), “Disasters” (16 papers or 13%), “Global Environmental Change” (13 papers or 10%) and “Natural Hazards” (10 papers or 8%).

Other documents represent approaches focusing on vulnerability and disaster risk reduction and integrate multiple sectors and disciplines. Figure 5.8 provides an overview of the disciplinary affiliation of the authors (The total number of papers in Figure 5.8 is 116, which does not represent all literature selected. This is because not all documents were published in journals and disciplinary affiliation could therefore not be determined).

Authors affiliated with environmental science account for the greatest number (18), followed by those affiliated with geography (17). The high number of geographers is likely to be related to the fact that vulnerability research has largely evolved from geography. Research on natural hazards can

be considered as a separate discipline. The number of authors affiliated with flood hazards and other hazards account for a total of 25.

Research on hazard vulnerability and disaster risk reduction has evolved considerably over recent decades into a multi-disciplinary field with a growing emphasis on integrating social science knowledge. Even though scientists affiliated with environmental science and geography were the authors of almost half of all selected documents, a total of 28 scientific disciplines were represented in the selected literature, from cultural anthropology to international business studies. Despite the contribution of so many disciplines, most of the studies reviewed take a mono-disciplinary approach, however. Authors are usually concerned with issues relating to their own area of expertise, and pay limited attention to other disciplines. For example, studies undertaken by atmospheric scientists tend to be concerned with the impacts of atmospheric factors, relative climate change, and sea level rise, and scientists in the medical field investigate the health-related impacts of hazards.

5.1.8. Geographical affiliation of the authors

In terms of the geographic affiliation of the authors, an overwhelming proportion of the literature relating to coastal hazard vulnerability in South & Southeast Asia was produced by scientists from North America and Europe (Figure 5.9). Figure 5.9 shows that of the 128 selected papers, only 15 were carried out by scientists based in the region, or affiliated with organizations that are based in the region.

This indicates that South & Southeast Asia are of great scientific interest for Western researchers and that most of the knowledge on hazard vulnerability is promoted by researchers (as shown in Figure 5.10), who might not be sufficiently familiar with local traditions, customs, formal and informal institutions, and other local factors that are likely to have important implications for social vulnerability. It also indicates the lack of capacity within these countries to undertake research of their own.

The analysis indicates that cultural differences between people in the affected communities and those providing humanitarian relief and recovery services to these communities, are considered an important factor contributing to hazard vulnerability. Southeast Asia is a region with its own unique history, cultures, perceptions, and religions, all of which are very different from Europe and America. The solutions and interventions for disaster risk reduction offered by the, mostly Western organizations might therefore not always be sufficiently sensitive to local traditions, customs and values.

The geographical bias of the scientists undertaking vulnerability assessments in the region is to a large extent based on the economic situation in the countries considered. Almost all of them are developing countries, and some of them are quite impoverished (e.g. some parts of India, Bangladesh, Malaysia). Therefore, the funds available for academic research are limited.

The low representation of locally based researchers also has implications for the incorporation of academic research insights into policy and decision-making processes in the formal and informal institutions of affected communities. It is increasingly recognised that, irrespective of the general validity of policy advice, it is critical to build effective institutions that fit within the local social and cultural context, rather than being externally imposed (Tompkins and Hurlston 2005).

5.1.9 The application of conceptual assessment frameworks

Within the selected literature nine different conceptual frameworks for vulnerability assessment were identified in 18 different documents (14% of all selected documents) (Table 5.2).

Some of these frameworks have been specifically developed for vulnerability analysis (e.g. (Wisner, Blaikie et al. 2003), (Ashley and Carney 1999) and (B.L.Turner, E.Kasperson et al. 2003)), while others originate in social theory, such as the theory of action (C.Bogard 1988) and the concept of equity (Cutter 1995).

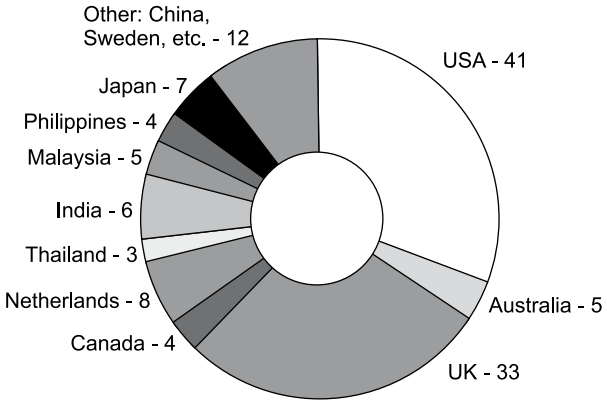

Figure 5. 9 Distribution of authors according to geographic affiliation

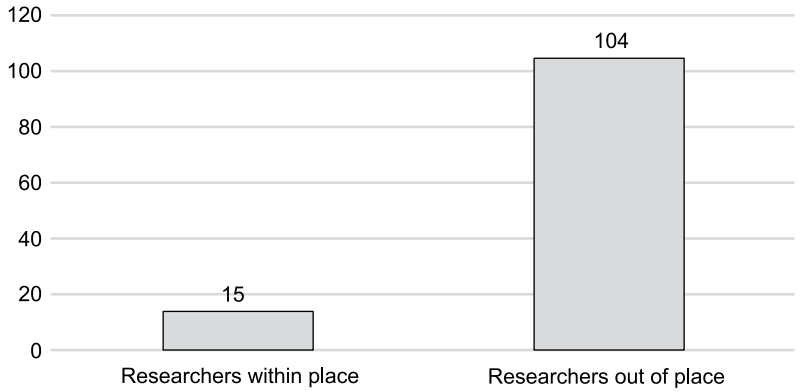

Figure 5. 10 Number of studies undertaken by local and international scientists

Researchers within place: from the same country of the case study, from Asia, or from some organizations in Asia (ADPC, ADB, etc.)

In all of the documents these frameworks were presented in the context of theoretical and conceptual review and discussion papers. There was not a single document in which one of the frameworks was actually applied in the analysis of a local or regional case study. This lack of application or operationalisation of conceptual work on vulnerability assessment in case study work, has been identified as a key challenge in vulnerability research (Kasperson, pers. comm., 2006).

Table 5. 2 Conceptual frameworks employed in the literature

Framework	Year	No. of times cited	Perspective on vulnerability
IPCC framework	2003	3	(IPCC definition) Def 1 (biophysical vulnerability): "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity." Def 2 (social vulnerability): degree to which a system is susceptible to injury, damage, or harm (one part - the problematic or detrimental part - of sensitivity)"
Blaikie 1994	1994	5	emphasises the social construction of vulnerability. vulnerability is equivalent to capacity and is largely determined by socio-economic structure and property relations
the Sustainable Livelihood prroach (SLA) framework of DFID	1999	2	No explicit definition on vulnerability but centered on people and their livelihoods. Considering people's assets (tangible and intangible); their ability to withstand shocks (the vulnerability context); and policies and institutions that reflect poor people's priorities.
McEntire's model of vulnerability	2001	3	Vulnerability is the dependent component of disaster that is determined by the degree of risk, susceptibility, resistance and resilience
Theory of action	1976	1	No explicit perception of vulnerability. It is a theory rooted in psychology, and widely adopted in economics and sociology.
Driver, pressure, state, impact, response (DPSIR) framework of UNEP	1994	2	The drivers are sometimes referred to as indirect or underlying drivers or driving forces and refer to fundamental processes in society, which drives activities having a direct impact on the environment. Human interventions may be directed towards causing a desired environmental change and may be subject to feedbacks in terms of environmental change, or could be intentional or unintentional by-products of other human activities. Environmental state also include trends, often referred to as environmental change, which could be both naturally and human induced.
Kasperson et al. (1988)	1988	2	The thesis of the framework of social amplification of risk, is that the impacts and influences of hazards would be amplified through the interaction processes of psychological, social, institutional, and cultural, then attenuate public responses to the risk event
Adger et al. 1999	1999	2	vulnerability can be seen as a socially-constructed phenomenon influenced by institutional and economic dynamics
Concept of equity	1992	1	Because of the unequility of social, general and procedural, women and children are more vulnerable.

5.1.10 The application of vulnerability indicators

Of the 128 selected documents only five discuss explicit indicators of vulnerability (Table 5.3). All of these relate to the assessment of vulnerability and potential losses at the national or regional level. Although some socio-economic factors such as literacy rate and energy consumption were mentioned as indicators, they were based on macro-level statistics that have little correlation with the case studies undertaken at sub-national scale.

Table 5. 3 Vulnerability assessments using explicit indicators

Authors	Year	Title	Scale	Field	Purpose	Indicators
Harold D. Foster	1976	Assessing disaster magnitude: a Social science approach	event	magnitude of all events	estimate the loss	4 : fatalities, injured, infrastructural stress value, affected population
C. Emdad Haque	2003	Perspectives of natural disasters in East and South Asia, and the Pacific Island States: Socio-economic correlates and needs assessment	national	natural hazards	predict 4 kinds of loss: deaths, injured, homeless damage in dollars	9 : Population size, population density, labour force, life expectancy, adult illiteracy rate, energy consumption, gross national product, GNP annual growth rate, urban population
Nick Brooks, W. Neil Adger, P. Mick Kelly	2005	The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation	national	climate change	assess national level vulnerability to climate change	11 : population with access to sanitation, literacy rate(15-24), literacy rate(over 15), maternal mortality, calorific intake, voice and accountability, civil liberties, political rights, government effectiveness, literacy ratio(F to M), life expectancy at birth
Marc J. Metzger, Rik Leemans, Dagmal Schruer	2004	A multidisciplinary multi-scale framework for assessing vulnerability to global change	regional or multi-scale	ecosystem	ecosystems assessment: exposure, sensitivity, adaptation potential impact, adaptive capacity, vulnerability, planned adaptation	5 categories consisting of detailed indicators: Increased climatic stress, decreases in demand, Changes agricultural communities and landscapes, decreased agricultural land, potential for high quality safe products

National level assessments provide a basis for comparisons of relative vulnerability between nations (e.g. (Brooks, Adger et al. 2005)). This is useful for targeting action by the international community on issues of global concern, such as climate change. For example, the IPCC identified those countries most vulnerable to sea-level rise (IPCC, 2001 – Third Assessment Report). However, because of the high aggregation of the indicators and indexes used in such assessments, they do not contribute to a detailed understanding of the underlying factors contributing to vulnerability on a lower scale and therefore do not support the identification of strategies at the sub-national levels of decision-making, for reducing vulnerability and building resistence.

5.2. The causes of vulnerability to coastal hazards

5.2.1 Distinguishing between different types of vulnerability causes

In the systematic review of the literature, the causes of vulnerability identified in the selected papers were documented and grouped into different categories (Tables 5.4 and 5.5). To be identified in this review as factors contributing to vulnerability, they had to meet two criteria: 1) they needed to have impacts on people's vulnerability to coastal hazards. This means that a change to the factor had to result in a direct or indirect change in vulnerability, and 2) the effect of the factor on vulnerability had to be negative, resulting in increased vulnerability to coastal hazards. For example, the factor group "Transportation" (I_1) indicates "poor transportation" or a "lack of transportation".

Similar syntheses of the causes of other phenomena undertaken in other fields of research distinguished between "underlying drivers" and "proximate factors", or "indirect drivers" and "direct drivers". For example, in the analysis of the factors of tropical deforestation (J.Geist and Lambin 2002)) identified three broad categories of proximate factors: infrastructure extension, agricultural expansion and wood extraction. Each of these categories consisted of a number of sub-factors. The underlying factors included the following five categories: demographic factors, economic factors, technological factors, policy and institutional factors, and cultural factors. Similarly, in the synthesis of the research on food insecurity, the drivers are indicated as direct and indirect (Misselhorn 2005).

This way of categorizing the causes of vulnerability introduces the problem of deciding whether a particular cause is direct or indirect (proximate or underlying). According to the definition of Turner et al (2001), vulnerability is a characteristic of all people, ecosystems, and regions confronting environmental or socio-economic stresses, and is driven by multiple interacting and cumulative processes operating at different spatial and temporal scales. Considering this complexity, the classification of causes as direct and indirect is a considerable challenge, and open to a large degree of interpretation. For example, in the synthesis of the factors contributing to food insecurity in South Africa ,(Misselhorn 2005) identified 17 direct and 11 indirect drivers. However 9 of these overlap because the boundary is not clearly defined and because some factors can be allocated to both categories, depending on the scale of analysis. Thus, categorizing vulnerability factors in this way did not appear to be particularly helpful in the context of this analysis and we therefore made no distinction between direct and indirect factors. Instead we grouped the factors in categories relating to socio-economic characteristics and disaster risk reduction aspects.

During a first general analysis of the selected literature, we found two ways in which the authors looked at vulnerability: One considered how vulnerability is affected through a wide range of socio-economic aspects. The other focused on the effects on vulnerability of disaster risk reduction activities. In the former, society is regarded as the object of analysis. Here, human activities and the interactions between the natural environment and social development are considered. In the latter view, the measures and actions in different phases of the disaster risk reduction cycle are considered and their effectiveness in reducing vulnerability is discussed.

Those factors grouped according to socio-economic characteristics and processes represent different aspects of daily social life without the consideration of disaster risk reduction (Table 5.4.). For

example, "Livelihood (L)" and "Infrastructure (I)" are two essential aspects of people's daily lives, but the roles of these two factor categories in different phases of disaster risk reduction are not considered. Although this way of categorizing is not explained explicitly in the selected documents, many authors used this system. This represents a "bottom-up" approach and is commonly applied in field-based case studies.

Other authors take the perspective of disaster risk management and discuss vulnerability factors in categories that relate to the four disaster risk reduction phases (Table 5.5). This is a "top-down" approach, and represents the priorities of policy makers. These two approaches are not independent or exclusive of each other but they illustrate two different perceptions of the factors contributing to disaster vulnerability: Focusing on socio-economic factors places emphasis on people's everyday lives and activities, while the focus on disaster risk management aims to develop and improve strategies, guidelines and an integrated structure for decision making and policy.

Table 5.4 provides an overview of the categories of socio-economic factors of vulnerability to coastal hazards. We identified a total of nine categories, nine sub-categories and 54 individual factors. The "Development" category includes two sub-categories: "Agricultural Activity" (DE_A) and "Land Use" (DE_L). The "Social Culture and Behavior" (SC) category includes two sub-categories: "Perception and Behaviour" (SC_P) and "Social Structure" (SC_S). Under the "Organizations" (IN_O) sub-category of the category "Institutions" (IN), there is a third level consisting of "Structure" (IN_SO) and "Characteristics" (IN_CO). Each sub-category is further subdivided into individual factors. For example, the sub-category "Agricultural Activity" (DE_A) of the category "Development" (DE) includes the factors "Trend in Agricultural Intensity", "Crop Diversity", and "Agricultural Land Availability".

It should be noted here that, because we did not adopt a pre-determined system for categorising the factors, they may not include all possible socio-economic factors, but represent only those identified in the selected literature.

The factors relating to disaster risk management were organized into the categories "Mitigation", "Early Warning", "Response" and "Post-disaster recovery" based on the system by (Hodgkinson and Stewart 1991; Helbing and Kuhnert 2003) (Table 5.5). In this study, we renamed the preparation phase "Early Warning" because early warning is generally regarded as the most direct and effective way of preparation, and none of the selected papers discussed any other preparations. Because disaster risk management needs to be an integrated process, there should in theory be no separation of the socio-economic factors and the disaster risk management related factors of vulnerability. In other words, the application of effective disaster risk management activities requires consideration of the socio-economic conditions. However, this need for integration is not reflected in the selected literature. Most studies do not consider the social circumstances of vulnerability in the analysis of disaster risk management strategies, rather they discuss the socio-economic factors and those relating to risk management separately. For this reason, we decided to present them in two different tables (Tables 5.4 and 5.5).

5.2.2. The relative importance of different vulnerability factors

In order to obtain an indication of the relative importance of different vulnerability factors, we analysed two types of data: individual causes of vulnerability and the frequencies with which these are mentioned in the selected literature. For example, the category "Livelihood" (L) consists of 8 separate factors, while the category "Geography and Environment" (GE) comprises 45 separate factors (Table 5.6.). The frequency of an individual factor represents the total number of times that factor was mentioned in the literature. The frequency of a category is defined as the total number of times all individual factors in that category were mentioned in the selected literature, without considering the diversities between the individual factors. For example, the frequency of the category "Human Condi-

tions and Basic Rights" (S) is 164. This means that the 16 individual factors within that category were mentioned a total number of 164 times in the selected literature.

We identified a total of 361 factors contributing to vulnerability to coastal hazards and these were mentioned a total number of 1,527 times. Of these, the total number of socio-economic factors was 287 (80%), and the total number of factors relating to disaster risk management was 72 (22%). Socio-economic factors were mentioned an average of 5.5 times and disaster risk management factors an average of 3.4 times.

5.2.2.1 Socio-economic factors

Table 5.6 shows the total number of identified factors contributing to vulnerability within each category and the number of times they occur in the selected literature. The total number of factors within a category ranges from 4 in "Macro economy" to 66 in "Institutions". Assuming that the number of factors relating to a particular category and the total number of times a factor, or factor category, is mentioned in the literature, is an indication of their relative importance, we can conclude that institutional factors are considered to be the most important, followed by "Geographic and Environmental" factors and "Infrastructure" factors.

The percentage of the number of factors (= the number of factors within a category, divided by the total number of factors in all categories), and the percentage of the number of times mentioned (= the number of times one factor is mentioned divided by the sum of the number of times mentioned of all factors) should be similar or close. The same goes for categories and sub-categories. But the results in this analysis show that there are differences in the real counting. Figure 6.6 indicates that, in the categories "Geography and Environment" (GE) and "Human Conditions and Basic Rights" (S), the "percentage of the number of times mentioned" is much higher than the "percentage of the number of factors" (25.4% compared to 16.2% and 10.4% compared to 5.8%, respectively). By contrast, the percentage of the factors in the category "Institutions" (IN) is almost double the percentage of the times mentioned (23.8% to 12.9%). Therefore, we concluded that in these documents, the "Geography and Environment" factors were considered more important than the "Institutions" factors. Another reason for the difference is that the "Geography and Environment" factors are recognized more widely as explicit factors of vulnerability than the "Institutions" factors.

The factors in the category "Geography and Environment" possess the highest total and the highest percentage of times mentioned. These factors include location (place) and local environmental factors, such as the type of terrain, elevation, and climatic conditions. Within this category, "Geographical and Environmental factors" (GE), such as environmental degradation, deforestation and climate change, are considered to be the most important environmental changes contributing to hazard vulnerability. Climate change is the second most frequently mentioned cause of vulnerability and the focus of a large proportion of the literature. Climate change impacts are expected to manifest themselves in the form of hurricanes, floods and other coastal hazards. In some of the reviewed documents, climate change was considered a man-made hazard, because the hazard can be controlled by mitigation (reducing greenhouse gas emissions).

The category "Human Conditions and Basic Rights" (S) includes five factor groups relating to resource entitlement, including both social and natural resources: national poverty, individual poverty, access to resources, power relations, and inequality. In total, the 16 individual factors of vulnerability in this category were mentioned 164 times and account for more than 10% of the frequency of all factors. Some researchers (e.g., (Adger and Kelly 1999) argue that the basis for any examination of social vulnerability is an understanding of the human use of resources. Access to resources is determined by the distribution of entitlements. Therefore, the extent to which individuals and groups (communities) are entitled to these resources determines their ability to cope with, and adapt to stresses/stressors. For this reason, factors in the category "Human Conditions and Basic Rights" (S) are of great importance throughout the selected literature. From a sociological point of view, there is a basic assumption that

Table 5. 4 Socio-economic factors contributing to vulnerability to coastal hazard

major categories of factors	**Human condition & basic rights**	**Development (DE)**		**Macro economy (M)**	**Livelihood (L)**	**Infrastructure (I)**
sub-categories of factors	**(S)**	**Agriculture activity (DE_A)**	**land use (DE_L)**			
factor groups	national poverty (S_1)	trend of agriculture intensity (DE_A_1)	land use policies (DE_L_1)	market liberalization (M_1)	resource distribution (L_1)	transportation (I_1)
	individual poverty (S_2)	Crop diversity (DE_A_2)	urban development (DE_L_2)	Globalized economy (M_2)	social networks (L_2)	coastal flood protection (I_2)
	access to resources (S_3)	land availability for agriculture (DE_A_3)	industrial development (DE_L_3)	labour and products market (M_3)		housing and shelters (I_3)
	Power relations (S_4)		physical changes to the natural land scapes (DE_L_4)	structure of economy (M_4)		Basic services (I_4)
	inequality (S_5)					river channels and reservoirs (I_5)
						others (I_6)

Institutions (IN)				Social Culture and Behavior (SC)		Demog-raphy	Geography and Environ-ment (GE)
Policies (IN_P)	organizations (IN_O)		others (IN_ OTH)	percep-tions and behaviour (SC_P)	social structure (SC_S)	(D)	
	structure (IN_SO)	charac-teristics (IN_CO)					
social wel-fare policies (IN_P_1)	hirerarchy of managing body (IN_ SO_1)	institu-tional culture (IN_ CO_1)	political situation	religious percep-tions (SC_P_1)	conflicts or strife (SC_S_1)	popu-lation density (D_1)	environmental characteristics (GE_1)
communica-tion of poli-cies (IN_P_2)	cooperation between agencies (IN_SO_2)	bureauc-racy (IN_ CO_2)	techno-logical solutions	perception from past experience (SC_P_2)	tradi-tional networks (SC_S_2)	migration (D_2)	geographical characteristics (GE_2)
participa-tion in policy making processes (IN_P_3)	government resources (IN_SO_3)		docu-mented knowl-edge and experi-ence	cultural norms (SC_P_3)	com-munity structure (SC_S_3)	gender (D_3)	environmental changes by human activi-ties (GE_3)
political bias in decision makings (IN_P_4)			govern-ment capacity	individual behaviour (SC_P_4)	house-hold structure (SC_S_4)	children (D_4)	
				cultural and lan-guage differences (SC_P_5)		popu-lation structure (D_5)	

Table 5. 5 Factors contributing to vulnerability relating to disaster risk management

Disaster risk management phase	Mitigation (MI)	Early Warning (EW)	Response (RE)[1]	Post-disaster recovery (R)
Factors	planning and preparedness (MI_1)	dissemination of warnings (EW_1)	response plans (RE_1)	medical service (R_1)
	assessment (MI_2)	Development of early warning systems (EW_2)	available resources (RE_2)	outside assistance (R_2)
	knowledge management (MI_3)	perceptions of warnings (EW_3)	governmental actions (RE_3)	aid distribution (R_3)
		poor communication of warnings (EW_4)	cooperation and assistance (RE_4)	institutional perception and behavior (R_4)
		information and knowledge (EW_5)	knowledge and experience (RE_5)	action of affected people (R_5)
				knowledge and information (R_6)

1 Though only one paper focuses on the exact "response" to disasters, which means the measures or activities during events, these factors are not only drawn from the one paper, but also from references in some reviews and general discussion papers.

access to resources is predominantly determined by state institutions (Bromley 1992), and that most entitlements to material assets are legitimized by government and formal laws. However, these institutions do not always completely act rationally or effectively (here "rational" carries the same meaning as in economics). Institutional decision-making is a complex process based, on the one hand, on the accumulation of knowledge based on past experience and tradition. On the other hand it is influenced by the constantly changing values and perceptions of contemporary society. Because of these complex institutional dynamics it is difficult to determine which institutional aspects particularly affect vulnerability. Despite this, institutions are widely acknowledged as important causes of vulnerability. In the selected literature, the factors in the category "Institutions" (IN) represented the largest percentage of all factors (23.8%) but ranked only fourth in the frequency they were mentioned (12.9%). Some institutional causes were only mentioned once in the selected literature. Two examples are the responses "not clear who to turn to when in such events" (Rodolfo and Siringan 2006) and "low collective security degree" (Kelly and Adger 2000).

Even though many different aspects relate to hazard vulnerability, the main focus of the selected literature is the analysis of hazard impacts and associated damages and losses. In all of the documents, poverty, including household-level and national-level poverty, was considered as a fundamental cause of hazard vulnerability. Environmental degradation, response measures, geographical background and institutional policies also ranked highly in importance.

Figure 5.12 shows the thematic focus of the 46 selected case studies. A comparison of this figure with Figure 5.11 reveals that the most frequently mentioned factors found in the entire selected body of literature are not consistent with those in the case studies. Five (or 33%) of the thematic foci in the case studies related to the impacts of hazards. This indicated a greater academic attention to the analysis of hazard impacts, rather than the factors of vulnerability.

Table 5. 6 The number of individual factors in each major category and their recorded frequencies

Major categories of factors	Number of individual factors	Total number of times mentioned	Percentage of number of factors	Percentage of times mentioned
Human conditions and basic rights (S)	16	164	5,8	10,4
Development (DE)	35	194	12,6	12,3
Macro economy (M)	4	26	1,4	1,7
Livelihood (L)	8	48	2,9	3,1
Infrastructure (I)	43	207	15,5	13,2
Institutions (IN)	66	203	23,8	12,9
Social-Cultural and Behavior (SC)	24	107	8,7	6,8
Demography (D)	36	225	13,0	14,3
Geography and Environment (GE)	45	400	16,3	25,4
Total	277	1574	100,0	100,0

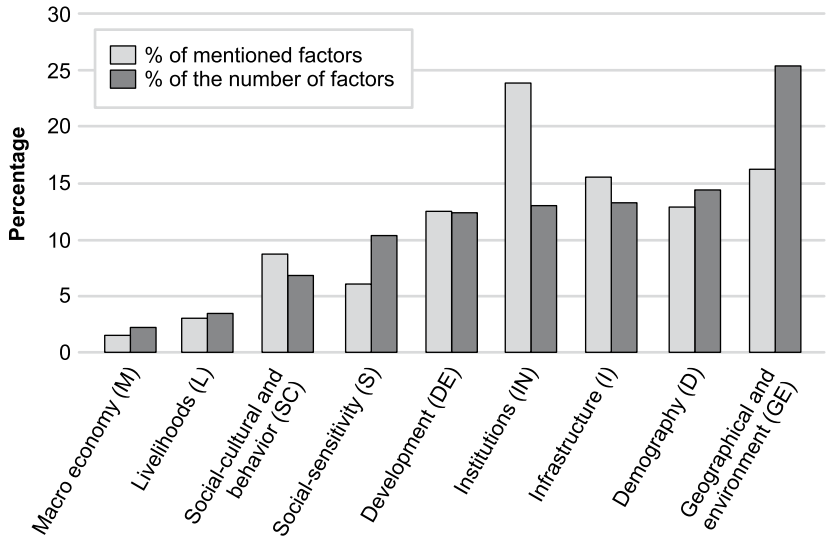

Figure 5. 11 Percentages and frequencies of socio-economic categories of factors

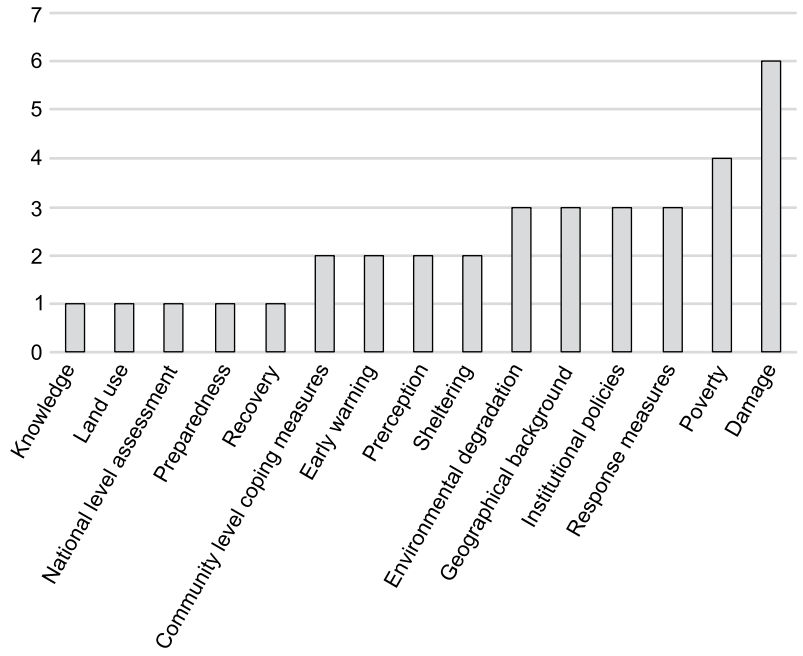

Figure 5. 12 Thematic focus of the 46 selected case studies

5.2.2.2. Disaster risk management factors

Compared to the large number of identified socio-economic factors contributing to vulnerability (277), we identified only 72 factors relating to disaster risk management (Table 5.7). These were mentioned a total number of 253 times. As described in Section 5.2.1, we grouped these factors into the categories "Mitigation" (MI), "Early Warning" (EW), "Response" (RE) and "Recovery" (R), representing the four phases of the disaster risk management cycle. Figure 5.13 shows the percentages and frequencies of the number of factors within each category. These statistics clearly indicate that of the four categories, "Response" received the least attention in the literature. In contrast to the high variance observed in the percentages and frequencies of the socio-economic factors of vulnerability, in the categories of risk management the frequencies are in proportion with the percentages of the number of factors in every category. Thus the number of factors in a given category was used as an indicator of the relative importance of that category.

We identified 8 factors of vulnerability relating to the disaster response phase. This phase has the shortest time duration of the four disaster risk management phases and corresponds to the time of impact of the disaster and its immediate aftermath. For many coastal hazards, such as tsunamis, tropical cyclones and tidal surges, most of the losses, especially the loss of human life, occur during the short time period of the initial impacts of the disasters in line with the 20-80 principle ,also known as Pareto principle,(the 80-20 rule, the law of the vital few, and the principle of factor sparsity, stating that for many phenomena, 80% of the consequences stem from 20% of the factors. (http://en.wikipedia.org/wiki).) The effectiveness of the response phase has implications for the planning of post-disaster recovery activities. An ineffective response phase could diffuse the impacts of disasters both spatially and temporally, and increase demands on the recovery efforts. Even though the speed of response actions is crucial - a fact which was not mentioned by any documents in the collected literature - there were five other factors in this category: response plans, available resources (including human, financial and material resources), governmental actions, cooperation and outside assistance, and knowledge and experience (Table 5.5). The fact that each one of these factors was mentioned only once or twice indicates that this phase was given relatively little attention in the selected literature.

Table 5. 7 Number of vulnerability factors in the four categories relating to disaster risk management in the selected literature

Major categories of factors	Number of individual factors	Total number of times mentioned	Percentage of number of factors	Percentage of times mentioned
Mitigation (MI)	19	75	26,4	29,6
Early Warning (EW)	23	80	31,9	31,6
Response (RE)	8	28	11,1	11,1
Rehabilitation (R)	22	70	30,6	27,8
Total	72	253	100,0	100,0

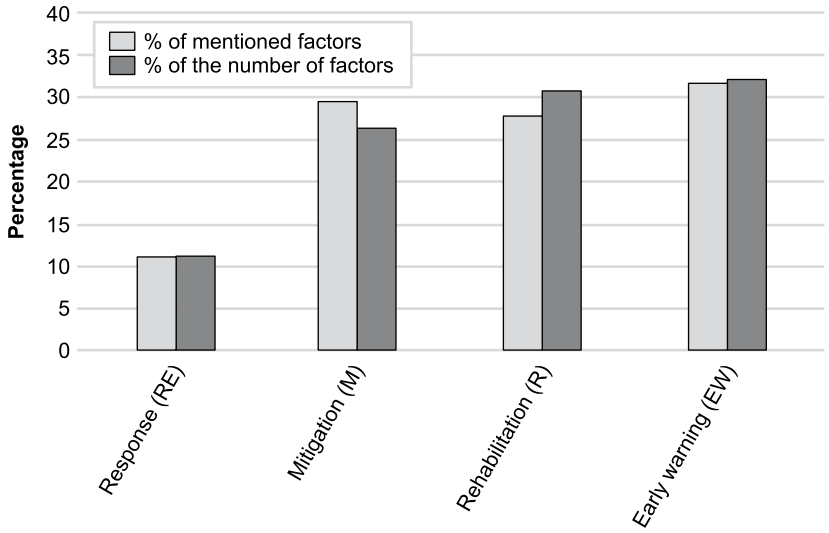

Figure 5. 13 Percentages and frequencies of the categories of vulnerability factors relating to disaster risk management

5.2.3. The most important individual causes of vulnerability

The number of times individual factors were mentioned varied considerably. The 20 most frequently mentioned factors contributing to vulnerability to coastal hazards listed in Table 5.8 represent only 6% of all 361 factors, but the sum of their frequencies accounted for more than 30%.

To obtain the list of the 20 most mentioned factors (Table 5.8) the factors of both socio-economic and disaster risk management were included in the statistical analysis. However, the results do not include any factors relating to disaster risk management. The most frequently mentioned categories are “Geography and Environment” (GE), “Human conditions and basic rights” (S), “Development” (DE) and “Demography” (D). The “Human Conditions and Basic Rights” category accounts for 25% of the number of individual factors and for more than 20% of the frequencies of individual factors in the top 20. The “Development” (DE) and “Demography” (D) categories both account for 15% each of the number of individual factors and for 15% and 18% of the frequencies of individual factors in the top 20 (Table 5.9).

Factors relating to “Geography and Environment” are considered to be the most important in contributing to vulnerability to coastal hazards. They were mentioned more than twice as many times as

Table 5.8: The 20 most frequently mentioned individual factors contributing to vulnerability to coastal hazards

	Code	Total number of times mentioned	Individual factor contributing to vulnerability
1	D_1_1	44	population growth
2	GE_1_1	34	climate change
3	GE_2_7	33	change in the level of rainfall
4	DE_L	30	development and land use change
5	S2_1	28	individual poverty
6	GE_2_2	27	low-lying coastal land
7	D_1	26	high population density
8	GE_1_2	26	sea-level rise
9	DE_L_4_6	25	deforestation
10	GE_2_6	24	high wind during monsoon season
11	L_1_2	23	habitation of high-risk marginal areas
12	GE_1_8	23	contaminated fresh water
13	S3_1	22	lack of access to assets and entitlements
14	DE_L_3_2	18	poorly planned industrial development
15	GE_1_3	18	timing of disaster
16	GE_1_9	18	post-disaster disease incidence
17	D_2	17	migration
18	S1	16	national poverty
19	S3_4	16	resource (political, economic, social, etc.) dependency
20	S5	16	social inequality

the next highest category. The most frequently mentioned individual factors in this category are climate change, changing rainfall patterns, low-lying coastal land, and sea-level rise.

The second and third most mentioned factors belonged to the categories “Human conditions and basic rights” and “Demography”. Within the category “Human conditions and basic rights”, the most frequently mentioned cause was individual poverty, followed by lack of access and entitlements, national poverty, and inequality. The most important demographic factors were population growth, population density, and migration.

5.2.4. The most vulnerable individuals and social groups

Even though the vulnerability of different social groups to coastal hazards depends on a variety of factors, it is generally acknowledged that those marginalized by poverty and limited entitlements tend to be the most vulnerable (e.g. Kasperson, IPCC, 2001, others?). Our review confirmed this. In the literature we analysed, 27% of documents that investigated differential hazard vulnerability identified women as the most vulnerable social group, followed by children (19.6%) and the elderly (16.7%). People with disabilities tended to be placed in the same category as elderly people.

In rural areas local, cultural, and ethnic factors were considered more important than economic and institutional factors in causing differential vulnerability. In addition to women, children and the eld-

Table 5. 9 Statistical analysis of the 20 most frequently mentioned factors contributing to vulnerability to coastal hazards by category

Category	Number of factors within this category	Percentage of the number of factors in this category in the top 20	Sum of times mentioned of all factors in this category 1	Percentage of frequency of all factors in this category in the top 20
Geography & Environment (GE)	8	40	203	41,94
Human conditions and basic rights (S)	5	25	98	20,25
Demography (D)	3	15	87	17,98
Development (DE)	3	15	73	15,08
Livelihood (L)	1	5	23	4,75

1 For example, Table 6.4 shows that there were five factors in the category "Human conditions and basic rights" (S): S1, S2_1, S3_1, S3_4 and S5. These were mentioned 16, 28, 22, 16 and 16 times, respectively. Therefore, the "sum of times mentioned" of all factors in this category is 16+28+22+16+16=98.

erly and disabled, daily farm labourers and fishermen were also recognized as vulnerable in rural areas because of uneven access to natural resources, including land, water, and forests, and social resources, such as political representation. Although both of these groups tended to be poor and highly vulnerable, fishermen were generally considered to be more vulnerable because they tended to be isolated from other communities and the most exposed to the physical forces of coastal hazards (Thompson and Sultana 1996). In urban areas industrial workers and low-earning families were identified to be particularly vulnerable (U.S.De, Khole et al. 2001).

Gender was found to be the main determinant of vulnerability because women have less physical strength and they have the special burden of children and their role as carers, which is more pronounced in rural areas. However, the situation in urban areas is not much better than in rural areas. The existing division of labour makes women poorest (Thompson and Sultana 1996). The street children in Metro Manila are vulnerable because they have no access to resources to withstand flood hazards and because they are highly exposed to environmental contamination and diseases (B.Zoleta-Nantes 1996).

Some researchers (Adger and Kelly 1999; Cross 2002) argue that people in rural areas are more likely than those in urban areas to lose their lives or health as well as other means of living .Reasons for this are the limited access to natural and social resources in rural areas on the one hand and the existence of an "urban bias" in disaster risk reduction on the other.. For example, some researchers have suggested that some pre-event hazard mitigation efforts have been aimed at protecting larger urban centres by sacrificing smaller or rural communities (A.Cross 2002; Manuta and Lebel 2004).

Governance and disaster risk reduction strategies can spread risks by diversifying patterns of resource use and by encouraging alternate activities and lifestyles. "Social memory", both of individuals and institutions, includes practices, knowledge, values, and world views, and is crucial for preparing for change, building resilience, and for coping with surprises (Adger, P.Hughes et al. 2005). On the one hand, it can be an accumulation of experience and knowledge, on the other it can lead to inertia and bureaucracy on the part of the authorities (Manuta and Lebel 2004; Clasen, Smith et al. 2006; Takeda and Helms 2006).

5.3. Interactions between individual factors contributing to vulnerability

5.3.1. Demography, land use and environmental degradation

Figure 5.14 is a conceptual map of the relationships between demographic factors, land use and environmental degradation in creating vulnerability to coastal hazards. The numbers on the arrows indicate the number of times that particular causal relationship was mentioned in the selected literature. The figure illustrates that population growth and migration are considered to be important causes of land use changes and environmental problems that affect a wide range of human activities.

According to Morrow (1999), demographic trends are motivated by the pursuit of economic and material resources, human or personal resources (such as education), family and social resources (such as networks of reciprocity) and political resources (such as power and autonomy). For example, the choice to live in marginal or hazardous places is usually made by poor people who seek material resources for their livelihoods. Migration to urban areas tends to be motivated by the prospects of better education and job opportunities or the desire to join relatives already living in the city.

It is important to note the relationships between the factors relating to land use and environmental change: overgrazing, the intensive use of floodplains, and deforestation all lead to environmental degradation, which, in turn, is an important cause of vulnerability, through the creation and perpetuation of poverty and inequality. In line with the findings of the analysis undertaken by (Geist and Lambin 2002), we found that demographic processes and economic development are important factors of environmental degradation.

In their meta-analysis of the factors of deforestation, Geist and Lambin (2002) identified demographic factors (population growth, migration, population density and distribution) and economic factors (market growth and commercialization, economic structures, urbanization and industrialization) as the underlying factors driving proximate factors such as infrastructure extension and wood extraction. Although the categorization of the factors of vulnerability to coastal hazards in this study is not identical with that of Geist and Lambin's (2002), both studies show that population dynamics and economic development and the interactions between them, are the principle factors of environmental degradation.

5.3.2. Interactions between environmental factors

Figure 5.15 is a conceptual map of the relationships between the environmental factors contributing to vulnerability. The factors we identified as the most important in this context were climate change, deforestation and the lack of sufficient flood protection infrastructure. Climate change leads to changes in various hazard characteristics, such as the timing and frequency of hazards (IPCC, 2001) and challenges the capacity to cope of many communities, particularly in developing countries in South and Southeast Asia.

Climate change impacts directly on people's daily lives. For example, climate change, along with sea-level rise, leads to the reduction of crop yields (Winchester 2000), which in turn is one of the drivers of migration.

Inadequate, or poorly constructed, or poorly maintained flood protection infrastructure can lead to the structural vulnerability of buildings and infrastructure, an increase in soil salinity, and the contamination of freshwater resources. The availability of clean drinking water is particularly important in reducing vulnerability, especially in the post-disaster recovery phase. Some of the deaths associated with coastal hazards have been attributed to a lack of drinking water in shelters and the spread of epidemic diseases (Winchester 2000).

As shown in Figures 5.14 and 5.15, the factors relating to development, demography, environment and infrastructure are all closely interlinked. For example, the increasing demand for land that results from population growth and immigration, is one of the main causes of the destruction of coastal ecosystems, such as mangrove forests, wetlands and sand dunes. In turn, the destruction of these ecosystems reduces the natural sheltering effect during storms and tsunamis (e.g. Adger et al, 2005; Miller

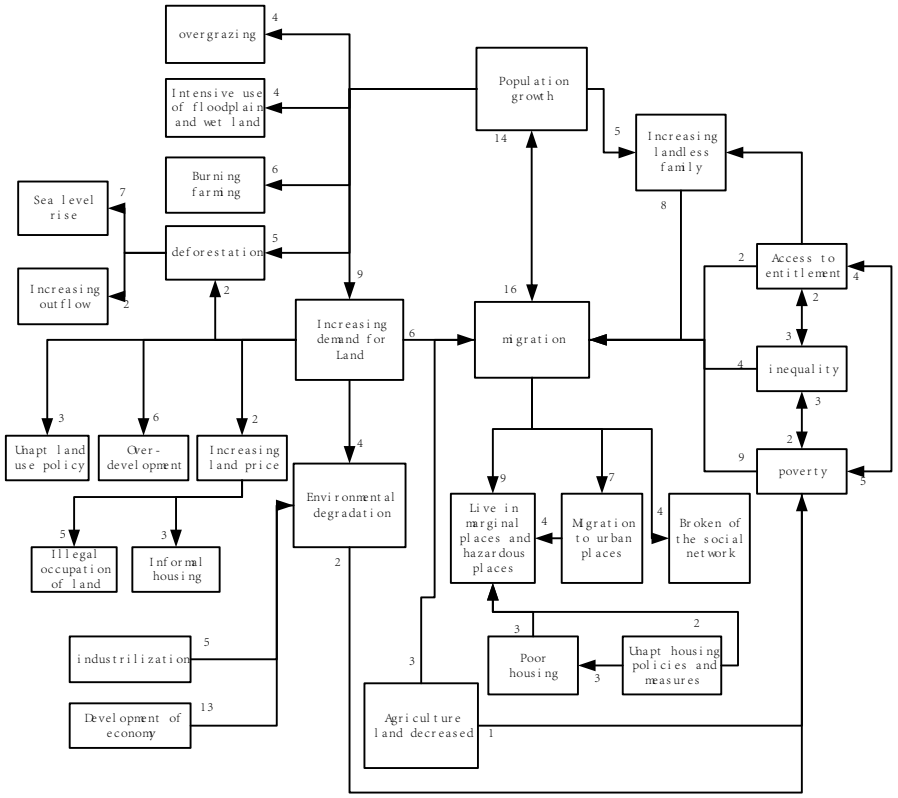

Figure 5. 14 Conceptual map of the relationships between demographics, land use and environmental degradation in creating vulnerability to coastal hazards

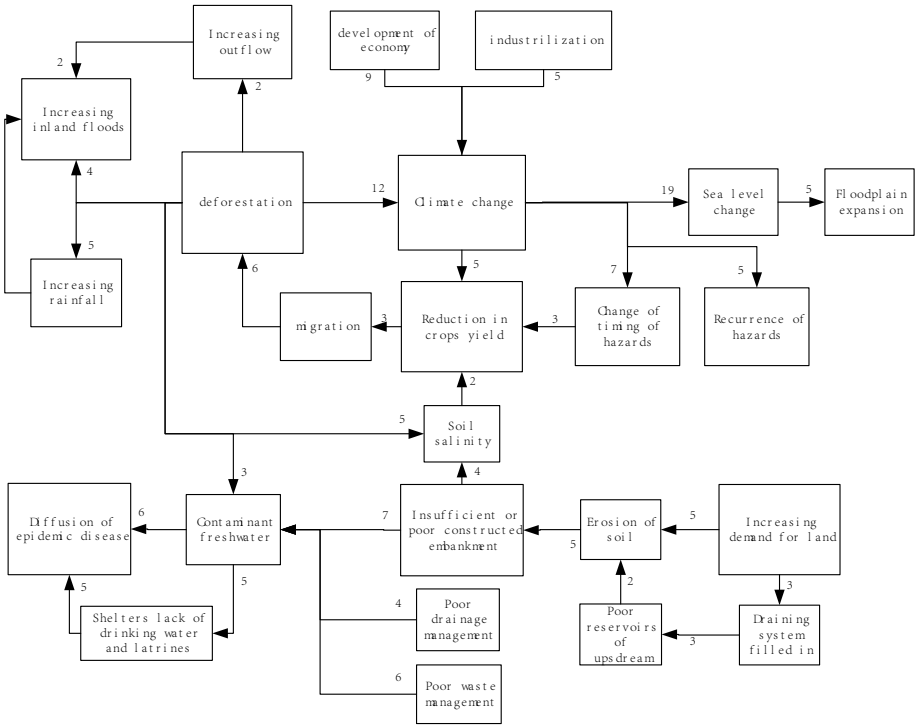

Figure 5. 15 Conceptual map of relationships between environmental factors of vulnerability

et al., 2006), negatively affects future economic development (e.g.(Turner R, S. et al. 1996; Haque 2003)), worsens climate conditions (e.g. (Kelly and Adger 2000; DE, KHOLE et al. 2004)), accelerates the flow of population to coastal areas (e.g. (SHAKUR 1998)), and affects access to resources (e.g.(Adger 1999; Cross 2002; Manuta and Lebel 2004)).

5.3.3. Interactions contributing to natural resource degradation

The dynamics of the demography and livelihood factors are partially driven by issues relating to access to natural resources. With increasing social and environmental changes, the demand for many important natural resources is growing and many of the world's resources are becoming increasingly degraded (Millennium Ecosystem Assessment, 2005). These resources are important in building communitiy-level coping capacity and resilience to natural hazards. Frequently, natural resources are destroyed or wasted because of short-sightedness and the lack of integrated environmental planning (Chan 1997). In particular, many developing and transition countries place greater emphasis on short-term national economic development and the improvement of living standards, than a longer-term balanced and fair development that considers the values of environmental assets for disaster risk reduction and other non-economic functions and services. The loss of resilience is often hidden and the importance of access to natural resources in reducing social vulnerability is often not appreciated until a disaster occurs (Adger, P.Hughes et al. 2005).

However, the importance of ecosystem health and functioning in building adaptive capacity and social resilience to natural hazards and other shocks and surprises, is increasingly being recognized (e.g. Adger et al., 2005, Miller et al., 2006). According to (B.Zoleta-Nantes 1996), the conversion of coastal wetlands and sand banks for aquaculture or agricultural production results in the loss of the natural protection function of coastal ecosystems, increasing the physical exposure to hazards of the people living in those areas. As resilience can be both eroded or bolstered accidentally or deliberately through human action, the loss of ecological and social resilience is difficult to document and quantify (Adger, P.Hughes et al. 2005).

Many coastal communities in Southeast Asia that have traditionally derived their livelihoods directly from terrestrial and/or marine based natural resources, such as fishing, small-scale agriculture and the use of forest products, are increasingly affected by wider socio-economic processes, such as urbanization, migration to the coast, increasing competition for coastal resources through different sectors, including in particular tourism (e.g. Calgaro, 2005) and large-scale aquaculture and palm oil plantations (e.g. Jäger et al, 2007). In many cases the authorities expropriate land from small-scale or subsistence farmers for industrial development without adequate compensation. This displacement drives the now landless farmers to clearing remaining areas of forest or wetlands and converting them into agricultural land. In developing countries with poor environmental protection laws or poor enforcement of such laws, natural resources are often exploited illegally, leading, in some cases, to severe environmental impacts (Chan 1997).

5.3.4. Power, access to resources and entitlements

Many vulnerability researchers (e.g. (Cutter 1995; Thompson and Sultana 1996; Haque 2003; Adger, P.Hughes et al. 2005; Calgaro 2005)) argue that, in many cases, existing power structures are an important obstacle in reducing hazard vulnerability. The lack of power and influence in decision-making has long been recognized as one of the most common factors of poverty (Carney 1999). Access to power determines the entitlement to natural and social resources and is reflected in the capacity to control and capture resources from different levels (Lebel, Garden et al. 2005). According to (Bhagavan and Virgin 2004), access to entitlements depends on relations, hierarchies and lines of command, division of labor and responsibilities, and channels of communication and information sharing. Therefore, political representation, access to social welfare, insurance and financial credit, as well as inequality and poverty, are all components of power. Our analysis confirms that lack of entitlements, inequality

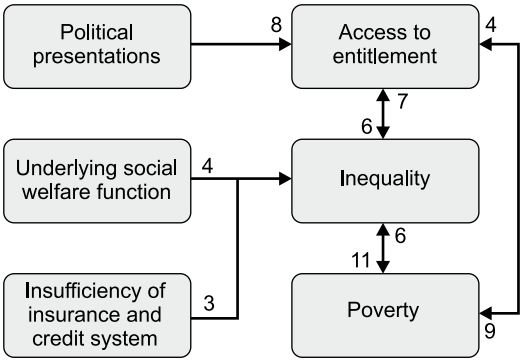

Figure 5. 16 Conceptual map of the underlying factors of vulnerability relating to power relationships

and poverty are all closely linked and considered highly important in constructing social vulnerability to coastal hazards (Figure 5.16).

Blaikie, Cannon et al. (1994) show that disasters are largely socially constructed. Entrenched political ideologies and power structures regulate access to resources and form the root factors of hazard vulnerability, as they exacerbate the dynamic pressures acting on communities and leading to unsafe conditions within a fragile environment and local economy (Tompkins and Hurlston (2005). Though many different definitions of entitlement exist, generally it can be described as the underlying basis of social structure (Cutter 1995; Lebel, Garden et al. (2005). There are two kinds of entitlements: entitlement to material resources and entitlement to power resources. The former is usually presented as access to wealth and the latter refers to political representation. The two kinds of entitlements supplement each other: entitlements to resources means not only that the access is permitted but also that the controller of the resource is obliged to grant the access when it is requested (Firozabadi and Sergot 2004). According toAdger, Brown et al.(2005), the decentralization of knowledge, resource and power results in the production of winners and losers. The distribution of entitlements is decided by the more powerful who tend to strengthen their own position and thereby reinforce the existing power structure and increase inequality. Such social constructs constrain people's thoughts and ability to act and therefore cause inequalities. External pressures such as the impacts of climatic extremes or other natural hazards tend to reinforce such inequalities (Cannon 1994).

Figure 5.16 shows that access to entitlements is based on the political representation of different groups. The limitation of access to entitlement, such as shortcomings of the underlying social welfare and insurance and credit systems, aggravate inequality. For example, in India, most of the losses resulting from natural disasters are not insured and therefore many people receive no financial compensation for the loss of life of family members or the loss of their livelihoods (Atmanand 2003). This lack of access to insurance and compensation aggravates vulnerability to future hazards.

5.4. Statistical analysis of the interactions between the categories of socio-economic causes of vulnerability

Several statistical analyses using SPSS for Windows (Version 11.0) were undertaken to provide an overview of the available data, to check the scientific objectivity of the method used to categorize the causes of vulnerability (Section 5.4.1 and 5.4.2), and to explore the causal relationships between them. In section 5.4.3 and 5.4.4, we analysed the interactions between individual causes of vulnerability, based on qualitative evidence derived from the selected literature. To gain additional insights into the relationships between the major categories of factors we undertook a series of quantitative statistical analyses of the matrix of the 9 main categories of socio-economic factors and the 120 selected documents, to determine data distributions, correlations and various general characteristics of the literature.

Table 5. 10 Correlations between the 9 major categories of socio-economic causes of vulnerability to coastal hazards

		S	DE	M	L	I	IN	SC	D	GE
S	Pearson Correlation	1	0,376(**)	0,112	0,329(**)	0,230(**)	0,542(**)	0,144	0,381(**)	0,035
	Sig. (2-tailed)	.	0,000	0,208	0,000	0,009	0,000	0,104	0,000	0,699
DE	Pearson Correlation	0,376(**)	1	0,148	0,199(*)	0,461(**)	0,215(*)	-0,015	0,452(**)	0,596(**)
	Sig. (2-tailed)	0,000	.	0,096	0,024	0,000	0,015	0,862	0,000	0,000
M	Pearson Correlation	0,112	0,148	1	0,340(**)	0,064	0,033	0,302(**)	0,210(*)	0,125
	Sig. (2-tailed)	0,208	0,096	.	0,000	0,471	0,713	0,001	0,017	0,161
L	Pearson Correlation	0,329(**)	0,199(*)	0,340(**)	1	0,281(**)	0,190(*)	0,571(**)	0,367(**)	0,237(**)
	Sig. (2-tailed)	0,000	0,024	0,000	.	0,001	0,031	0,000	0,000	0,007
I	Pearson Correlation	0,230(**)	0,461(**)	0,064	0,281(**)	1	0,208(*)	0,128	0,477(**)	0,494(**)
	Sig. (2-tailed)	0,009	0,000	0,471	0,001	.	0,018	0,149	0,000	0,000
IN	Pearson Correlation	0,542(**)	0,215(*)	0,033	0,190(*)	0,208(*)	1	0,240(**)	0,188(*)	0,003
	Sig. (2-tailed)	0,000	0,015	0,713	0,031	0,018	.	0,006	0,034	0,974
SC	Pearson Correlation	0,144	-0,015	0,302(**)	0,571(**)	0,128	0,240(**)	1	0,208(*)	0,081
	Sig. (2-tailed)	0,104	0,862	0,001	0,000	0,149	0,006	.	0,018	0,364
D	Pearson Correlation	0,381(**)	0,452(**)	0,210(*)	0,367(**)	0,477(**)	0,188(*)	0,208(*)	1	0,180(*)
	Sig. (2-tailed)	0,000	0,000	0,017	0,000	0,000	0,034	0,018	.	0,042
GE	Pearson Correlation	0,035	0,596(**)	0,125	0,237(**)	0,494(**)	0,003	0,081	0,180(*)	1
	Sig. (2-tailed)	0,699	0,000	0,161	0,007	0,000	0,974	0,364	0,042	.

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

5.4.1. Correlations between the categories of socio-economic causes

The correlation analysis (Table 5.10) indicated that the correlations between the 9 major categories of socio-economic factors were low (less than 0.600). However, some relevant observations could be made.

Factors in the category "Geography and Environment" (GE) were positively correlated with all other categories, and particularly highly with the categories "Development" (DE) (r = 0.596) and "Infrastructure" (I) (r = 0.494). This means that the factors in the GE category were not exogenous to the human-environment system, but were strongly influenced by socio-economic processes.

Wider macro-economic factors of vulnerability, operating on larger scales outside the location may affect socio-economic processes within it. The correlation analysis showed that the category "Macro-economy" (M) correlated positively with all other categories both externally and internally. A change in this category in one direction (positive or negative) therefore results in a change in the same direction ,in the other categories.

The category "Livelihood" (L) was influenced the most strongly by the category "Macro-economy" (M) (r = 0.340). This is because the process of economic globalization, which is one of the causes of vulnerability within the category "Macro-economy," (M) has direct consequences for people's livelihoods. For example, those people whose livelihood depends entirely on the production of cash-crops such as coffee (see e.g. Lindskog, Dow et al. 2005)), are particularly vulnerable to price fluctuations in the global market. Market liberalization also changes employment patterns.

Though many of the factors of both "Macro-economy" and "Geography and Environment" originate externally, they are differently correlated with other factors. Macro economic factors influence Sensitivities (S) more than geographic and environmental factors, with correlation coefficients of 0.112 and 0.035, respectively. Macro economic factors also have a stronger influence on factors of "Social Culture and Behavior" (SC) (r = 0.302) than do geographic and environmental factors (r = 0.081). On the other hand, geography and environment factors are more strongly correlated with factors of "Development" (DE) and "Infrastructure" (I).

The category "Human Conditions and Basic Rights" (S) was positively correlated with all other categories. The highest correlation was with "Institutions" (IN) (r = 0.542). This high correlation indicates the importance of entitlements to the access to resources in determining vulnerability to coastal hazards.

The only categories that were negatively correlated were the "Development" (DE) and the "Social Culture and Behavior" (SC) categories. Though the correlation was not statistically significant (r = -0.15), it indicated that they affected each other negatively. This relationship can be explained in two ways: Firstly, development frequently leads to migration and this weakens traditional social networks that are important components of social culture (Pantelic, Srdanovic et al. 2005). Secondly, migration changes social structures, such as community structure and household size (SCL 2002). Driven by the perceived opportunities to improve their well-being, many people voluntarily abandon their traditional culture and behaviour and embrace change. Because of the eagerness of governments in many developing countries to support rapid economic development, the conservation of cultural identity and traditions is frequently neglected.

5.4.2 Nonparametric tests analysis

We counted the frequencies of the factors mentioned in each article. Because we did not assume the underlying distribution of the factors in the literature to have any particular shape and because we assumed that the data was a random sample, we applied the nonparametric test as shown in Table 5.11. These test results showed that the mean frequencies of the categories (the total number of times all factors within a particular category were mentioned) ranged from 3.3594 ("Geography and Environment") to 0.1563 ("Macro-Economy"). The standard deviations also varied considerably (Table 5.11). These differences, verified by Chi-Square analysis, demonstrate significant diversities between the categories. The Chi-square test compares the observed and expected frequencies of each category

Table 5. 11 Descriptive Statistics and Nonparametric Test

	S	DE	M	L	I	IN	SC	D	GE
Mean	1,1328	1,7266	0,1563	0,4453	1,7031	1,7422	,9453	1,7969	3,3594
Std. Deviation	1,80276	2,58620	0,44257	0,89450	2,75326	2,25272	1,35918	2,63041	3,39925
Maximum	7,00	11,00	2,00	4,00	11,00	9,00	5,00	10,00	13,00
Chi-Square									
Chi-Square	260,000	269,969	169,750	232,469	317,469	178,984	149,406	259,813	108,031
Expected frequency	16,0	12,8	42,7	25,6	12,8	14,2	21,3	12,8	9,8
df	7	9	2	4	9	8	5	9	12
Asymp. Sig.	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Run test									
Test Value(a)	0,00(b)	0,00(b)	0,00(b)	0,00(b)	0,00(b)	1,00	0,00(b)	0,00(b)	2,00
Cases < Test Value	0	0	0	0	0	57	0	0	48
Cases >= Test Value	128	128	128	128	128	71	128	128	80
Total Cases	128	128	128	128	128	128	128	128	128
Number of Runs	1(c)	1(c)	1(c)	1(c)	1(c)	55	1(c)	1(c)	73
Z						-1,659			2,273
Asymp. Sig. (2-tailed)						0,097			0,023

a Median

b All values are greater than or less than the cutoff. The test run could not be performed.

c Only one run occurs. The test run could not be performed.

to test that all categories contain the same proportion of values. By default, all categories have equal expected values however in our results, the different Chi-squares (C^2), indicated significant differences between the frequencies of the categories. The distribution of the factors in the selected literature was also uneven. Because the sporadic distribution of the 361 factors in the 128 selected documents made the test on stochastic distribution of the factors unavailable, the test run could only be carried out for the factors in the categories "Institutions" (IN) and "Geography and Environment" (GE).

5.4.3 Cluster analysis

Although the nonparametric tests analysis revealed no pattern in the distribution of the factors of vulnerability identified in the selected literature, some observations could be made by undertaking a cluster analysis. The K-means cluster method was applied to undertake a Q-Type analysis of all documents. K-means cluster analysis is a tool used to assign cases to a fixed number of groups (clusters) whose characteristics are not yet known, but are based on a set of specified variables. Here, the number of times each category was mentioned was the determinant of the cluster. In the cluster analysis of the categories of the socio-economic factors contributing to vulnerability, the spaces between the clusters were largest when the records were divided into 5 clusters. The results are shown in Table 5.12 and Table 5.13. Table 5.12 also indicates the centre of each variable (category) in each cluster.

The cluster analysis shows that 88 of the 128 selected documents belong to cluster 4 (Table 5.13). These documents represent the lowest number of times each category was mentioned. This is in

Table 5. 12 Cluster analysis results of the selected literature (128 documents)

	clusters					F	Sig.
	1	2	3	4	5		
Human condition & basic rights (S)	1,50	3,14	1,83	0,49	3,00	14,957	0,000
Development (DE)	6,25	3,57	8,67	0,64	2,00	67,110	0,000
Macro economy (M)	0,25	0,00	0,17	0,13	0,32	1,037	0,391
Livelihood (L)	0,38	1,29	1,17	0,17	1,21	10,507	0,000
Infrastructure (I)	7,63	7,71	2,83	0,66	1,47	60,437	0,000
Institutions (IN)	1,63	3,86	2,67	0,78	5,16	34,123	0,000
Social Culture and Behavior (SC)	0,75	0,86	0,83	0,66	2,42	8,122	0,000
Demography (D)	3,75	7,86	4,17	0,98	1,79	23,475	0,000
Geography and Environment (GE)	11,63	3,14	7,67	2,08	4,53	39,841	0,000

Table 5. 13 Number of documents in each cluster

Cluster	1	8
	2	7
	3	6
	4	88
	5	19
Valid		128

accordance with the analysis of the dispersive distribution of the frequency of the factors in the selected literature (analyzed in "2.nonparametric tests").

The most important result is that there are a number of factors of vulnerability to coastal hazards that are highlighted as important by some researchers, but not considered at all in the vast majority of the reviewed documents. For example, in some of the selected documents in cluster 4, the geography of the particular case under investigation is presented simply as background information rather than as a contributing factor to hazard vulnerability. In other documents it is argued that vulnerability is affected by factors such as poverty, development and increasing population, but no analysis is provided to substantiate such superficial claims. This lack of in-depth analysis makes it difficult to develop a sophisticated understanding of the interactions between different factors.

Within cluster 1, the categories "Development" (DE), "Infrastructure" (I) and "Geography and Environment" (GE) are frequently mentioned. The factors in the category "Geography and Environment" (GE) were mentioned the most, with a frequency of 11.63. In these documents vulnerability tended to be analysed at a relatively theoretical and conceptual level and at larger scales, such as national, multinational or global. In some of them a strong link was made between vulnerability and development. For example, in (ADB 2004), hazard vulnerability is related to poverty and environmental degradation in the East Asian region. Another group of documents in this cluster focus more on geographical factors and analyze them from an engineering point of view (e.g.(Shaluf and Ahmadun 2006)).

Within cluster 2, factors relating to the categories "Demography" (D) and "Human Conditions and Basic Rights" (S) were mentioned more frequently than in any other cluster. The highest scores for these were 7.86 and 3.14, respectively. Even though the number of documents in this cluster was only 7, they rated demographic factors as important factors of vulnerability. Several of these documents identified women and children as the most vulnerable groups to coastal hazards. For example, Cutter's examination (1995) of the concept of environmental equity and its utility in relation to the sociospatial impacts of climate change and climate-related hazards, analyzed the capacity of different social groups to cope with and adapt to such changes, and identified women and children as the most vulnerable groups. (B.Zoleta-Nantes 1996) analysed the differentiated impacts of flood hazards on street children, the urban poor, and residents of wealthy neighborhoods in Manila in the Philippines. She concluded that, because of the limited access to various resources, street children and the poor tended to be more severely affected by flood hazards, and that it took these people longer to recover than those who had greater access to resources. Another group of articles in this cluster focused on the role of migration, and linked migration with factors operating on a broader scale, such as social sensitivity and institutional policies. For example, one study on the 1991 cyclone in Bangladesh, (Mushtaque, Chowdhury et al. 1993) regarded migration as an important cause of high mortality. They argued that because the new immigrants had less knowledge and experience of local hazards, they lacked the necessary coping strategies in those situations. On the other hand, the motivation for migration frequently lies in the hope of gaining better access to natural resources. immigration can lead to over exploitation of the natural resource base in the destination place and can be a source of conflict there (Cutter 1995; Thompson and Sultana 1996). The resulting environmental degradation may be a contributor to increased losses during disasters (Cutter 1995). Other articles pointed out that in some cases institutional measures encourage migration to marginal places. This kind of encouragement tends to occur indirectly, for example through policies that aim to establish "coastal industrial zones", by converting coastal wetland into rice farms and intensifying the use of coastal flood plains (e.g. (Bandyopadhyay 1997; Chan 1997; Imamura and To 1997)).

The documents in cluster 3 and cluster 5 contain similar average frequencies of all factor categories but the factors relating to category "Development" (DE) had the highest score of 8.67.

5.4.4 Interactions between the major categories of vulnerability factors

In Section 5.2 we presented the individual factors contributing to vulnerability to coastal hazards identified in the selected literature and in section 5.3 we analysed their relative importance in creating

coastal hazard vulnerability. In this section we present the causal relationships between the 9 major categories of vulnerability factors (Figure 5.17).

In this analysis, we documented the number of individual factors within each category and the number of times each identified causal relationship was mentioned. The number of times each causal relationship is mentioned is taken as an indicator of its importance. Causal relationships exist between categories as well as within them. For example, the factor "Failure in cooperation among different agencies" directly influences the factor "Failures of the bureaucratic approach of decentralized knowledge" (Takeda and Helms 2006).

Analysis indicated strong causal relationships between different vulnerability factors. For example, urban expansion and land cover changes were frequently associated with increasing population density, which in turn was mostly driven by factors relating to "Development" (DE), "Geography and Environment" (GE) and "Macro-economy" (M).

There were strong interactions between factors within the categories "Development" (DE) and "Human Conditions and Basic Rights" (S). Because development, through the implementation of management strategies and policies, aims to improve the well-being and coping capacity of nations, communities and individuals, it affects many other important aspects that have direct implications for hazard vulnerability. Examples include population dynamics ("Demography"), the construction of infrastructure ("Infrastructure"), and resource distribution and inequality ("Human Conditions and Basic Rights"). On the other hand, some aspects of "Human Conditions and Basic Rights" such as power relations, also determine the development process through institutional development policies and through demographical issues such as migration and gender (Cutter 1995).

Such feedback functions can amplify processes contributing to vulnerability and can lead to complex interactions. Although it is difficult to determine which are underlying drivers and which are proximate factors of vulnerability, we found that, generally, socio-cultural factors tended to operate at the lower (sub-national, community and household) levels, whereas institutional and demographic factors tended to influence vulnerability at higher (national, international and global)levels.

An additional layer of complexity arises from the interactions between factors at different levels. For example, we identified an important feedback loop between "Human Conditions and Basic Rights" (S), "Demography" (D) and "Development" (DE). Whilst the interactions leading to a particular outcome of vulnerability might be observed within the local context (place), the factors or driving pressures of these interactions frequently occur or originate at different levels externally. This also means that the interactions between local factors not only affect the vulnerability of that particular location, but that they also affected processes outside it through interaction with factors on a larger scale.

According to (Adger, P.Hughes et al. 2005), the factors of vulnerability are embedded in the political economy of resource use and the resilience of the ecosystems on which livelihoods depend. This analysis confirmed that factors relating to "Demography" (D) and "Geography and Environment" (GE) directly affected the greatest number of other factors. Factors relating to "Livelihood" (L) on the other hand, were affected by other factors but did not affect any other factors themselves.

"Social Culture and Behaviour" (SC) was mostly affected by "Geography and Environment" (GE) (6 links) and to a lesser degree by "Demography" (D) (3 links) and directly affected "Livelihoods" (L) (7 links). "Geography and Environment" (GE) has 2 links to "Livelihood" (L), and "Development" (D) has 4.

Factors in the category "Institutions" (IN) were directly affected only by those in the category "Social Culture and Behaviour" (SC) (3 links). The influence of cultural aspects, such as religion, cultural norms, traditional networks and social structures on institutional causes of hazard vulnerability tend to occur in the longer-term (several generations or longer). The analysis shows that in the short term (years) and medium term (decades) institutional characteristics and processes are considered to be relatively unaffected by other factors. Within this category we identified only 4 interactions between individual factors. These related to the impacts of earlier policies or institutional measures

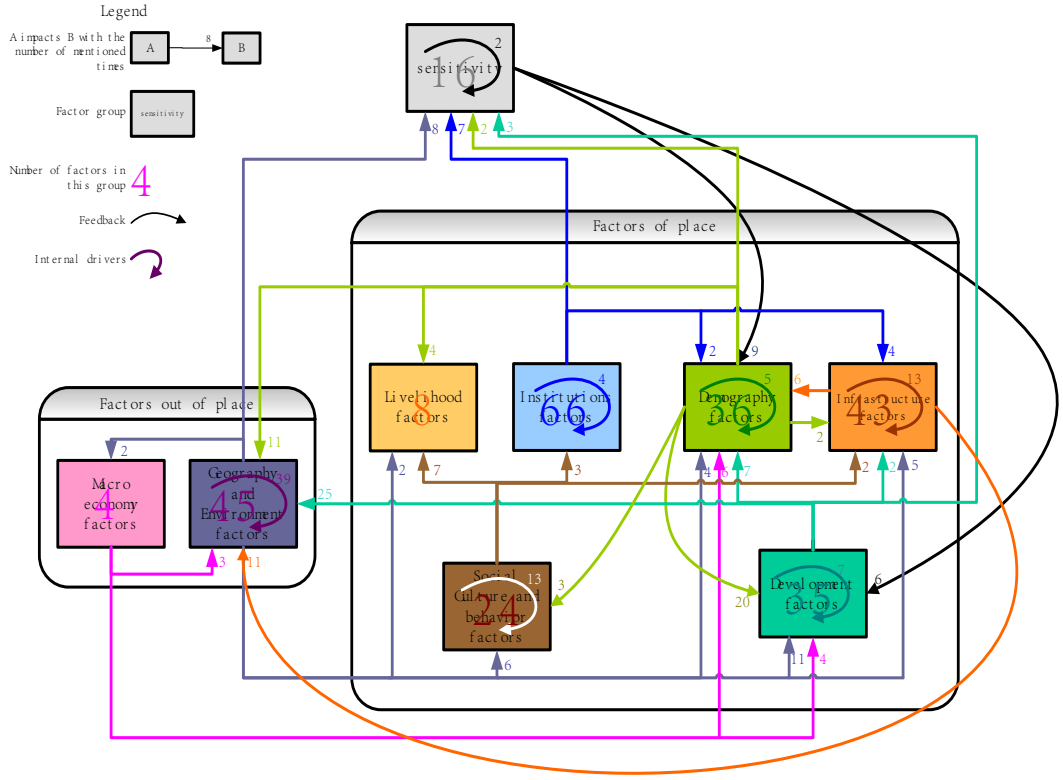

Figure 5. 17 The causal relationships between the different categories of vulnerability factors

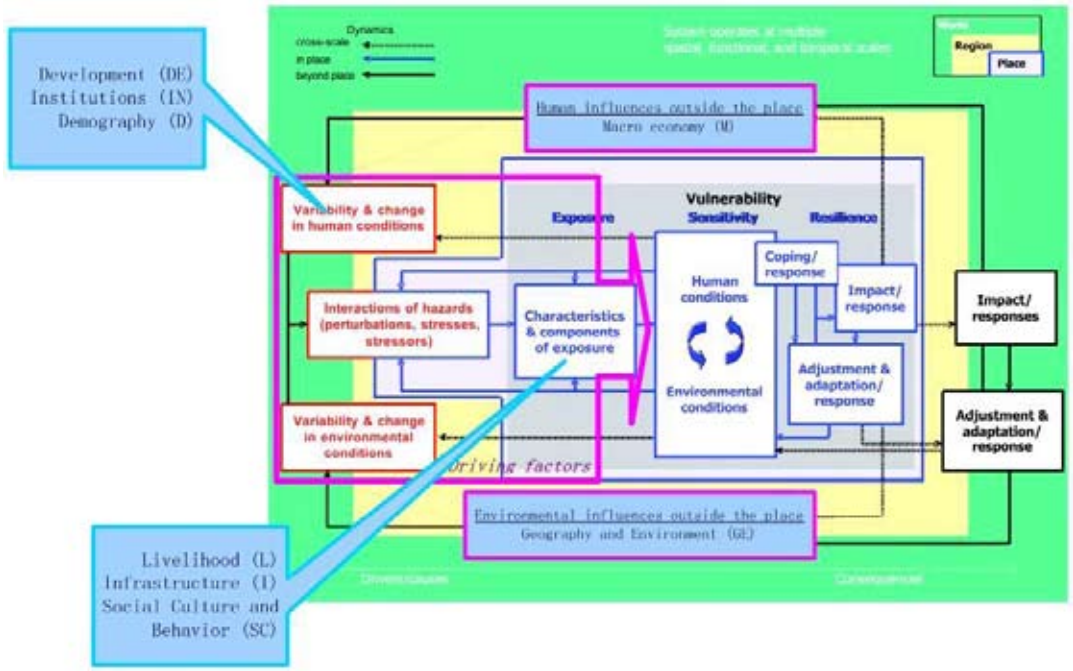

Figure 5. 18 Vulnerability factors mapped onto the Turner et al. (2003) framework

on more recent ones, as well as their impacts on the structure and characteristics of governments and institutions. Considering that this category included the largest number of identified individual factors (66), representing 23.8% of all identified socio-economic factors (Table 5.6) in 13 factor groups and 5 sub-categories (Table 5.4), these findings are alarming. They indicate that the mechanisms of the interactions between the institutional factors and other factors are not well understood, and that long-term causal relationships are not considered in the documents we reviewed.

5.4.5. Mapping the vulnerability factors onto the conceptual vulnerability framework

The factors contributing to vulnerability can be mapped onto the Turner et al. (2003) framework in the following way (Figure 5.18).

5.5. Identifying the recommendations to reduce coastal hazard vulnerability

5.5.1. Identification and categorization of recommendations

We identified a total of 227 individual recommendations relating to many different aspects of vulnerability and disaster risk reduction. These were grouped into 8 major categories: “Social-Cultural” (SC), “Institutions and Policies” (IN), “Recovery” (R), “Infrastructure” (I), “Environment” (E), “Community and Household” (CH), “Early Warning” (EW) and “Assessment” (A) (Table 5.14). Each of these categories was further sub-divided into a number of groups of recommendations (Table 5.14).

We did not apply the same categories we used to organise the different factors of vulnerability (socio-economic factors and disaster risk reduction factors, Section 5.2.1, Tables 5.4 and 5.5) because many of the recommendations focused on the higher policy level and did not correspond directly with the identified factors of vulnerability. For example, the group of recommendations named “Guidelines” (IN_G) and “General policies” (IN_GP) in the category “Institutions and Policies” (IN) contained only very general recommendations for vulnerability reduction, without any detailed guidance on how these broad aims might be achieved in practical terms. Typical examples of these kinds of recommendations were to: “Develop long term and stepped hazard management plans (IN_G)” and “Base entitlements to government resources on the survival needs of people (IN_GP)”.

Recommendations in the other groups focused more strongly on concrete policies that related to a particular cause of vulnerability. These included, for example, recommendations on insurance and welfare measures (IN_WP), development strategies (IN_DP) and improved co-operation between different institutions (IN_CP).

Generally, we found that a complete match between the identified factors of vulnerability to coastal hazards and the recommendations that address these specific factors did not exist. For example, migration was identified as a cause of vulnerability (category “Demography” (D), Section 5, Table 4) but the only recommendation relating to the demographical aspects of vulnerability was to control population growth (category “Guidelines” (IN_G).

In the categories “Institutions and Policies” (IN) and “Early Warning” (EW), there were many recommendations to improve co-operation in different areas of vulnerability reduction: Recommendations in the group (IN_CP) in the “Institutions and Policies” category refer to co-operation between different humanitarian and disaster risk reduction organisations, governments, and academic researchers, while those in the category “Early Warning” focus on the integration of local early warning systems with those in other regions.

Another important set of recommendations was in the link between development, ecosystem conservation, and hazard vulnerability: in the “Institutions and Policies” (IN) category, it was recom-

Table 5. 14 Categories of recommendations to reduce vulnerability to coastal hazards in the selected literature

Major categories of recommendations	Socio-Cultural (SC)	Institutions and Policies (IN)		Post-disaster Recovery (R)	Infrastructure (I)	Environment (E)	Community and Household measures (CH)	Early Warning (EW)	Assessment (A)
Groups of recommendations	Education (SC_1) 6	Guidelines (IN_G) 12	NGOs and other institutions (IN_NP) 12	Plans (R_1) 3	Flood protection (I_1) 10	Protocols and plans (E_1) 2	Protocols and plans (CH_1) 1	Construction of early warning system (EW_1) 4	Risk assessment (A_1) 2
	Traditional coping strategies (SC_2) 3	General policies (IN_GP) 7	Cooperation (IN_CP) 14	Aid distribution (R_2) 6	Transportation (I_2) 5	Reforestation (E_2) 3	Credit system (CH_2) 1	Dissemination of warnings (EW_2) 2	Needs assessment (A_2) 1
	Others (SC_3) 2	Micro level and livelihood (IN_MP) 15	Information and communication management (IN_IP) 11	Monitoring (R_3) 2	Housing and shelters (I_3) 10	Development control (E_3) 5	Local organisation and structure (CH_3) 6	Cooperation (EW_3) 1	Capability and liability assessment (A_3) 2
		Insurance, welfare and other measures (IN_WP) 7	Investments (IN_I) 8	Redevelopment (R_4) 4	Waterways and reservoirs (I_4) 7	Sea-level rise reduction (E_4) 3		Mass communication (EW_4) 4	Livelihood assessment (A_4) 4
		Development (IN_DP) 6	Others (IN_O) 3	Local facility (R_5) 5		Ecosystem restoration (E_5) 6			Impact assessment (A_5) 1
		Government organisation (IN_OP) 13				Water quality (E_6) 3			Protocols and guidelines (A_6) 5

Table 5. 15 The 20 most frequently mentioned individual recommendations to reduce vulnerability to coastal hazards hazards by group

	Code	Total number of times mentioned	Recommendation
1	SC_1_1	23	Encourage hazard education in the schools and the media
2	IN_CP_7	22	Improve communication between academic researchers, decision-makers and practitioners
3	IN_DP_1	18	Integrate hazard mitigation policies in national development plans
4	IN_CP_2	16	Encourage multi-national co-operation
5	IN_CP_5	16	Improve co-operation between communities and sectors
6	IN_CP_9	13	Improve co-operation between local institutions and NGOs
7	E_2_1	12	Initiate afforestation or reforestation programs
8	E_2_2	12	Initiate mangroves and shelter belt plantations
9	IN_G_9	11	Develop more bottom-up community-based recovery schemes
10	EW_1_1	10	Improve early warning system and communication
11	A_1_1	10	Take a comprehensive hazard risk assessment approach
12	IN_OP_3	9	Involve local stakeholders in the decision making, planning and implementation
13	IN_GP_7	8	Set up public laws related to disaster prevention and mitigation
14	IN_OP_2	8	Form an apex hazard-managing body and empower it
15	IN_CP_6	8	Enable longer-term co-ordination and partnership with the victims and the local authorities and actors
16	IN_I_7	8	Increase funding for flood control projects
17	IN_G_3	7	Improve literacy
18	SC_1_5	6	Practice the dissemination of warnings and conduct evacuation drills at appropriate intervals
19	IN_G_2	6	Reduce poverty
20	IN_G_6	6	Implement existing regulations

mended that disaster risk reduction policies should be integrated into national development plans and in the "Environment" (E) category, the recommendation was to delineate zones in which no development should be undertaken in order to protect coastal ecosystems.

5.5.2. Frequencies of the individual recommendations

Table 5.15 shows the 20 most frequently mentioned individual recommendations. Because every recommendation was recorded once for every document it appeared in, the number of times it was mentioned is equal to the number of documents that mentioned it. The most frequently mentioned recommendation (documented 23 times and in 20% of all papers) was hazard education in schools and in the media. This corresponded well with the statistical analysis of the factors of vulnerability (Section 5.2 and 5.3), which showed that risk perception and the behaviour of individuals were considered important by many researchers. In that analysis there were 16 factors in this category and these were

Table 5. 17 The 10 most frequently mentioned groups of recommendations to reduce vulnerability to coastal hazards ranked by different criteria

a) The 10 most frequently mentioned groups ranked by the number of recommendations

Groups of recommendations	Number of recommendations	Number of times mentioned
Micro level and livelihood (IN_MP)	15	43
Cooperation (IN_CP)	14	99
Government organization (IN_OP)	13	53
Guidelines (IN_G)	12	68
NGOs and other institutions (IN_NP)	12	22
Information and communication management (IN_IP)	11	31
Flood protection infrastructure (I_1)	10	37
Housing and shelters (I_3)	10	37
Investments (IN_I)	8	28
Waterways and reservoirs (I_4)	7	19

b) The 10 most frequently mentioned groups ranked by the number of times mentioned

Groups of recommendations	Number of recommendations	Number of times mentioned
Cooperation (IN_CP)	14	99
Guidelines (IN_G)	12	68
Government organization (IN_OP)	13	53
Micro level and livelihood (IN_MP)	15	43
Education (SC_1)	6	39
Flood protection infrastructure (I_1)	10	37
Housing and shelters (I_3)	10	37
Information and communication management (IN_IP)	11	31
Development (IN_DP)	6	28
Investments (IN_I)	8	28

c) The 10 most frequently mentioned groups ranked by the average number of times mentioned

Groups of recommendations	Number of recommendations	Number of times mentioned	Average number of times mentioned
Reforestation (E_2)	3	26	8,7
Risk assessment (A_1)	2	16	8,0
Cooperation (IN_CP)	14	99	7,1
Education (SC_1)	6	39	6,5
Credit system (CH_2)	1	6	6,0
Impact assessment (A_5)	1	6	6,0
Guidelines (IN_G)	12	68	5,7
Dissemination of warning signals (EW_2)	2	10	5,0
Development (IN_DP)	6	28	4,7
Government organization (IN_OP)	13	53	4,1

mentioned 64 times or an average of 4 times. Inappropriate behaviour was identified as a cause of loss of human life (Gupta and Sharma 2006), both during hazard impact and in the recovery phase.

5.5.3. Frequencies of the groups of recommendations

Each of the major categories of recommendations in Table 5.14 contained a number of individual recommendations that reflected the wide range of aspects pertaining to a particular issue discussed in the literature. In order to obtain an understanding of the relative importance of these different aspects, we organized the recommendations that were concerned with broadly the same issues into smaller groups. We then undertook a statistical analysis of these 41 groups (Table 5.16).

The statistical analysis revealed that recommendations on co-operation ranked the highest. Table 5.16 shows that among the ten groups in the top 20 recommendations measured by the number of times mentioned, recommendations relating to co-operation alone accounted for 32.8%.

Accounting for 13.1% of the recommendations in the top 20, the second highest ranking group was institutional and policy guidelines (IN_G). The average number of times these recommendations were mentioned was 7.3. The second and the third most mentioned recommendations related to cross- level communication and cooperation (Table 5.17).

Table 5.17 lists the 10 most frequently mentioned groups of recommendations ranked by the number of recommendations within each group, the number of times the group was mentioned, and the average number of times individual recommendations were mentioned within that group.

Table 5.17.a and Table 5.17.b indicate that although the top 10 groups of recommendations span a wide range of issues, recommendations relating to institutions and policies dominate regardless of the ranking method.

The recommendations in the category “Institutions and Policies” (IN) are the most frequently mentioned and account for more than half of the top 20 recommendations, both in terms of the number

of individual recommendations, and in terms of the number of times mentioned (Table 5.15). Within this category, the group "Micro Level and Livelihood" (IN_MP) contained the largest number of recommendations (Table 5.17a). These included guidelines on community level disaster risk management and many suggested measures for governments or authorities to reduce vulnerability and build resilience. For example, some of the recommendations focused on the promotion of individual and community empowerment and responsibility, others on providing institutional measures to protect the property of evacuees.

However, when we calculated the average number of times each individual recommendation was mentioned, the group "Cooperation" (IN_CP) ranked the highest in the number of times mentioned and second highest in the number of individual recommendations. This included co-operation between academics, decision-makers and practitioners; between different nations; between various levels of decision-making, from the global to the community level; between communities and sectors; co-operation with NGOs, civil society organizations; and the participation of affected people in decision-making processes during the recovery process. For example, (Bandyopadhyay 1997) emphasized the need to improve collaboration between NGOs, civil society and the private sector. Others (REAVILL and RAHMAN 1995) noted the need for longer-term co-ordination and partnership with those affected by disasters and with local authorities and actors involved in post-disaster recovery. The recommendation to improve communication between academic researchers, decision-makers and practitioners was documented 22 times and was the most mentioned recommendation within this group. The need to improve the flow of information from science to practice is vital in order to provide a solid knowledge base to underpin effective disaster risk reduction. However, such linkages rarely exist (Haque 2003; McEntire 2005) and it is increasingly noted that, although research on vulnerability and disaster risk reduction has been undertaken for several decades, much of it remains highly theoretical and conceptual and is of limited operational value.

When we calculated the average number of times the recommendations in each group were mentioned (Table 5.17c), "Reforestation" (E2) ranked the highest, with an average number of times mentioned of 8.7. This group included only 3 recommendations, but the recommendation to plant coastal mangroves and natural shelter belts was made 12 times (e.g. (Green 2004; Arya, Mandal et al. 2006; Shaw 2006). This indicates that considerable importance is given to the role of the natural environment in reducing hazard vulnerability.

Within the category "Infrastructure" (I), the groups "Flood Protection" (I_1) and "Housing and Shelters" (I_3) each included 10 recommendations and were mentioned more than 30 times. This suggests that the provision of protective infrastructures was considered an important part of reducing hazard vulnerability. However, some researchers (REAVILL and RAHMAN 1995) regarded the increasing reliance on flood protection infrastructure as a key factor in the increasing losses due to flood hazards.

5.5.4. Frequencies of the categories of recommendations

Finally, we undertook a statistical analysis of the 8 major categories of recommendations on how to reduce vulnerability to coastal hazards (Figure 5.19, Table 5.18). Also at this aggregate level, "Institutions and Policies" (IN) was the most prominent category, accounting for 47.6% of the total number of recommendations and 54.2% of the number of recommendations of all categories mentioned in the selected literature. The category consisted of 11 groups of recommendations that spanned a wide range of issues (Table 5.14). The group "Micro level and livelihood" (IN_MP) included the most individual recommendations (15), followed by the groups "Cooperation" (IN_CP) and "Government organization" (IN_OP), with 14 and 13 recommendations, respectively.

"Infrastructure" (I), which contained recommendations relating to the construction of flood protection infrastructure, shelters and housing, transportation, and the management of waterways and reservoirs, ranked second highest.

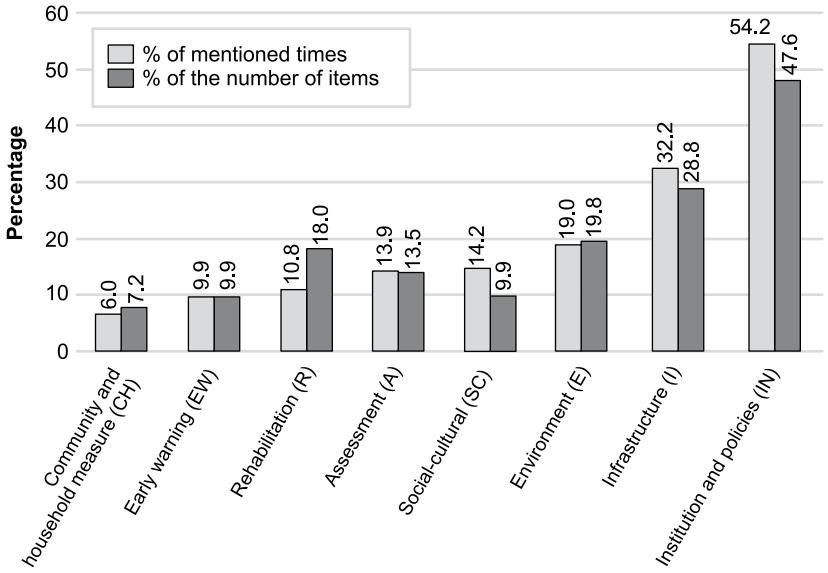

Figure 5. 19 Percentages and frequencies of the categories of recommendations

Table 5. 18 Number of recommendations in the 8 categories in the selected literature

Categories of recommendations	Number of recommendations	Number of times mentioned	Percentage of items in all recommendations	Percentage of mentioned times of items in the category
Institution and Policies (IN)	108	417	47,6	54,2
Infrastructure (I)	32	107	14,1	13,9
Environment (E)	22	63	9,7	8,2
Social-Cultural (SC)	11	47	4,9	6,1
Assessment (A)	15	46	6,6	6,0
Post-disaster Recovery (R)	20	36	8,8	4,7
Early Warning (EW)	11	33	4,9	4,3
Community and Household (CH)	8	20	3,5	2,6

The category "Community and Household" (CH) contained the fewest individual recommendations, and these were mentioned the least number of times in the literature. This category differs from that of the group "Micro level and livelihood" (IN_MP) in the category "Institutions and Policies" (IN), because it relates to community-based ("bottom-up") disaster risk reduction strategies, while the IN_MP recommendations target local authorities and institutions on the implementation of vulnerability reduction policies ("top-down" approaches).

As shown in Figure 5.19 and Table 5.18, the category "Post-disaster Recovery" (R) included 20 recommendations and these accounted for 8.8% of the total number of recommendations identified. However, these were only mentioned 4.7% of the time and scored the lowest average number of times

mentioned (1.8). This indicates that many recommendations have been made to improve the post-disaster recovery process but that they received consideration only in very few documents.

Most recommendations, with the exception of those relating to "Early Warning" (EW) (dissemination of early warnings) and "Post-disaster Recovery" (R) (aid distribution), focused on longer-term measures for achieving a reduction in vulnerability. This indicates a general recognition that the reduction of vulnerability to coastal hazards requires a commitment to longer-term processes. However, the analysis also shows that there is a lack of explicit suggestions as to how to improve strategies for the immediate disaster response phase (e.g., (Mileti 1999).

6. KEY INSIGHTS

Research on social vulnerability to natural hazards and environmental change has been undertaken since the 1960s. Even though the loss of human life has been significantly reduced over the last few decades through the implementation of various disaster risk reduction strategies, there is an increasing trend in terms of the number of reported natural disasters, the number of people affected, and the overall socio-economic impacts of these disasters. The reduction of social hazard vulnerability therefore remains a key international challenge to-date.

Considering the wealth of research on natural hazards, environmental risks and human vulnerability and well-being, as well as the practical experience relating to disaster risk reduction efforts all over the world, it is surprising that the attempts of researchers and practitioners to reduce hazard vulnerability have resulted in such limited success. The analysis presented in this report resulted in a number of interesting insights which might help to explain why this might be the case.

This analysis is the first attempt to provide a macro view of the current status of academic research on coastal hazard vulnerability in South and Southeast Asia. Previous reviews have mostly focused on the development of different conceptual frameworks for analyzing risk and vulnerability to natural hazards, and how these concepts have changed over time. We did not analyse the theories on hazard vulnerability or the advantages and limitations of different conceptual assessment frameworks. Rather, by undertaking a comprehensive comparative analysis of a large body of scientific literature we aimed at systematically documenting the causal factors thought to contribute to social vulnerability to coastal hazards, analysing their relative importance, mapping their complex causal interactions, and considering the synergies and mismatches between vulnerability factors and the recommendations put forward to reduce vulnerability. We also investigated a range of general characteristics of the selected literature, including the research disciplines and geographical backgrounds of the authors that have predominantly contributed to this area of work, the approaches and methodologies that have been applied to assess vulnerability, and the scales at which the analysis was undertaken.

This analysis confirms that vulnerability to coastal hazards is not only related to the characteristics of the hazards themselves, but that it tends to be also strongly affected by socio-economic processes and characteristics. Social structure, hierarchy, power relations, culture and tradition, access to resources and other characteristics, which have different impacts on the creation and extent of vulnerability, are formed through longer-term historic and cultural processes. Such factors are rarely considered in policy making because they tend to be highly systemic in many societies. Because they are deeply ingrained in culture and risk perception they are difficult to challenge.

6.1. The most important factors in creating vulnerability to coastal hazards

The analysis of the causes of vulnerability to coastal hazards presented in Section 5.2 indicated that many of the 20 most frequently mentioned factors related to demographic processes. Population growth was the highest ranking single cause, and population density, migration, and the tendency of people to live in marginal and hazardous areas were also frequently mentioned factors. These were

followed in importance by factors relating to human conditions and basic rights, particularly national and individual poverty, lack of access to resources, inequality and marginalisation (Table 5.6).

When considering the relationships between different factors of vulnerability (Figure 5.10), those relating to human conditions and basic rights were considered to strongly influence other causes of vulnerability. Figure 5.10 shows that poverty, lack of access to resources and inequality were important determinant factors of demographic processes, particularly migration. Demographics in turn affected most other factors of vulnerability.

6.1.1. Increasing influence of regional and global processes

In the last few decades globalization and the liberalisation of international trade has led to the establishment of new population dynamics around the world. As economies are becoming increasingly interconnected and interdependent, coastal communities are increasingly affected by processes occurring at larger scales (Adger, P.Hughes et al. 2005). For example, in regions where people are highly dependent on the production of cash crops for their livelihoods, such as coffee and rubber, their hazard vulnerability is strongly affected by fluctuations of global market prices for those commodities (e.g., Lindskog et al, 2005).

6.1.2. Population dynamics

Migration is considered one of the most important factors contributing to hazard vulnerability. It is generally perceived as one of the main causes of overexploitation of natural resources, environmental degradation, and the exacerbation of existing inequalities and tensions over access to resources. Migration includes large-scale population flows between countries or world regions and smaller-scale population flows, such as migration from an inland mountain area to a coastal area within the same country (e.g., Lindskog et al. 2005) and can be temporary or permanent. Global population dynamics are often regarded as “economic migration”. This type of migration typically involves production and consumption patterns that involve different industries. Tourism is a typical example causing temporary (seasonal) movement of large numbers of people across regions. Although this movement is short term, it represents a significant part of population dynamics. The 2004 Indian Ocean Tsunami highlighted the vulnerability of tourists and people working in the tourism sector, to coastal hazards (Calgaro, 2005). Due to the relatively short duration of their stay, tourists rarely acquaint themselves with potential hazards at their host destinations. Their poor knowledge of local hazard characteristics and institutions and procedures for disaster risk management make tourists particularly vulnerable. Also, early warning information tends to be less accessible to international tourists because the warnings are frequently not communicated in a language they understand and because tourists are difficult to reach due to their high mobility. Many of these issues also affect international economic migrants seeking employment in the expanding manufacturing industries in the rapidly developing economies in South and Southeast Asia. Market liberalization and economic globalization create opportunities and growth in the region and many of the countries aim to provide a better investment environment by creating special industrial zones. These zones are frequently located along the coast and separate investors and foreign employees from local communities. People living and working in these zones tend to have more limited access to hazard warnings than people in well established local communities.

A third kind of migration occurs at national, sub-national and local scales, where poor people living in rural communities move to other rural communities, or urban areas, to gain better access to natural resources, employment opportunities and education. For example, in the 1980s the Kinh residents in some villages in the Dak Lak Province in Viet Nam, migrated to make a better living by trading in fertilizers and insecticides (Lindskog et al. 2005). Many poor people move to coastal areas to obtain access to common-pool coastal and marine resources (e.g., Shakur, 1998; Brenner, 2001). This migration to the coast leads to population growth and increasing population density in coastal areas. This in turn increases the demand on coastal resources and leads to over-grazing, slash- and -burn farming, deforestation and intensive use of floodplains and wet lands (Figure 5.10). Increasing demand for land

also leads to higher land prices, overdevelopment and inappropriate landuse policies with far-reaching consequences in many other areas.

6.1.3. Socio-economic characteristics

The industrial structure and economic situation of a country have important implications for its hazard vulnerability. Most documents that focus on a particular country are about Bangladesh, India, and Vietnam. One reason for this is that these countries are located in geographic regions that are highly exposed to frequent and severe tidal surges and tropical storms. In addition, these countries are characterized by a high economic dependence on agricultural production, extremely uneven access to resources, and high levels of poverty. at the individual and national level.

Causes of vulnerability relating to development and infrastructure are closely linked to socio-economic processes. The countries considered in this review are all developing countries and transition countries, in which the achievement of strong economic growth is of high priority and socio-economic changes have been occurring rapidly. In these countries, traditional small-scale and subsistence farming is increasingly replaced by large-scale commercial agricultural production. Crop diversification and intensification, as well as landuse changes through industrial development and urbanisation is leading to profound changes in the geography and environment of many coastal areas. Infrastructure development, such as the construction of flood embankments, artificial channels and reservoirs, transforms the environment and affects ecosystem functioning and ecosystem services.

6.1.4. The role of institutions in creating and perpetuating vulnerability

Institutions. both explicitly and implicitly, determine the power structure within a given society and thus the access to social and natural resources. A disaster can therefore be understood as the product of a cumulative set of decisions taken over long time periods (Comfort, Wisner et al., 1999). For this reason, it is important to understand the processes by which decisions are made. The results of our analysis show that factors relating to institutions affect almost all other causes of vulnerability to coastal hazards, ranging from the choice of development pathways and practices to demographical dynamics and poverty, and marginalisation. The effect of other factors on institutional factors on the other hand, is very small. Factors of institutional structure and institutional characteristics are affected only by social culture. Social culture consists of people's perceptions and social structure, both of which are the results of longer-term historical processes. Social culture involves various aspects such as religion, history, values and social norms. These kinds of informal institutions have a profound effect on hazard vulnerability. For example, some researchers e.g., Atmanand, 2003; Takeda and Helms, (2006) noted that issues such as bureaucracy, fear of competition, local protectionism and corruption can all prevent outside aid from reaching those with the greatest need. Others e.g., Thompson and Sultana, (1996) argue that institutional learning is an important process in the reduction of vulnerability, but provide no specific recommendations on how such a learning process could be better supported.

6.1.5. Cooperation and power relations

The extent and effectiveness of cooperation between different actors is not only determined by the need to share information, but also by the expectations and intentions of the different stakeholders and the power relations between them. There are many discussions about the connotations and structures of power, and their central focus is an understanding of the application of action, knowledge, and resources in resolving problems and furthering interests (Few, 2002). Thus, the distribution of power can be considered to provide the underlying structure of society and this structure influences many aspects of social systems, including cooperation.

Cross-level cooperation is often motivated either by the potential benefits to particular stakeholders or the high costs of not undertaking them. The gains from such interactions are often uneven (Adger et al., 2005). The essence of this kind of cooperation between decision-makers and communities is the linkage between resource users on the one hand, and regulators and government agencies on the other

(Anderies et al., 2004). In traditional top-down management approaches a regulatory framework is imposed on resource users, with little or no decision-making power of resource users and civil society. Such management systems can lead to locked-in patterns of resource use that are frequently not sustainable and therefore create risks (Holling and Meffe, 1996). They also hinder the transparent, equal and fair distribution of humanitarian aid and compensation in post-disaster situations (e.g., Manuta and Lebel, 2004; Clasen et al., 2006).

Good cooperation between government authorities and civil society enables everyone, including the poor and marginalized, to play a role in making decisions about the allocation of resources and in overseeing government decision making processes (Carney, 1999). This involves the decentralization of power and control over resources, a process that requires the willingness of national governments to reduce their own power.

6.2. The most important recommendations for reducing vulnerability

We identified more than 200 individual recommendations for reducing vulnerability (Table 6.14). Tables 5.15 and 5.16 indicate that the 20 most frequently mentioned recommendations focused predominantly on the following four issues: increasing hazard awareness and knowledge, improving early warning systems and evacuation procedures, improving communication and cooperation between different actors, and strengthening environmental protection and post-disaster rehabilitation.

6.2.1. Increase hazard awareness and knowledge

Increasing hazard awareness and knowledge was the most frequently made recommendation to reduce hazard vulnerability (Tables 5.15 and 5.16). Individual recommendations included calls to increase awareness of potential hazards, establish appropriate response and coping strategies, and to conduct periodical emergency drills. Such measures tended to be targeted particularly at poor people living in rural coastal communities and people who recently migrated to coastal areas. The main suggested channels for achieving these aims were school programmes and media campaigns. Some researchers (e.g., Shakur, 1998; Haque, 2003) stressed the importance of increasing general literacy in reducing hazard vulnerability.

6.2.2. Improve early warning systems

Many researchers e.g., Mushtaque et al.,(1993; Kelly and Adger,(2000) considered effective early warning systems a key component of disaster preparedness and response. Thus many recommendations in this area focused on the improvement of risk assessment methodologies and early warning systems. There was a clear emphasis, however, on improving the technological “hard” elements of such systems with little consideration of the “soft” components, such as appropriate mechanisms for the communication and dissemination of early warning information to end-users (“last mile”) and the linkages with community-based disaster preparedness activities.

6.2.3. Improve communication and cooperation

Our analysis revealed a strong need to improve cooperation and communication between the many different actors operating in areas and sectors involved in reducing hazard vulnerability. Both vertical and horizontal cooperation is needed. Vertical cooperation refers to cooperation between authorities and communities and includes the sharing of information as well as the sharing of control over power and resources through the participation of local communities in the decision making process. Horizontal cooperation occurs between different government authorities and between such authorities with other stakeholders, such as non-governmental and civil society organizations and researchers.

We documented recommendations to improve cooperation between the following stakeholders:

- Between government authorities and civil society: This includes nongovernmental, humanitarian, and civil society organisations, particularly local institutions and national and international aid organizations (e.g., Thomalla and Schmuck, 2004).

- Between different levels of government and different departments.
- Between decision-makers and those directly affected by disasters: Improved cooperation between decision-makers and affected communities is expected to make decisions and policies more relevant to local situations. Disaster risk reduction measures frequently do not take into account the cultural or religious traditions of local communities. For example, some people do not seek refuge in cyclone shelters because of their religious perception, or fatalism, (e.g., Kurita et al., 2006). Other reasons why particularly poor people tend not to evacuate are the loss of income and fear of losing property to looters (e.g., Haque and Blair, 1992).
- Between researchers, policy-makers and practitioners.

Recommendations for improving cooperation are aimed not only at the response and recovery phases, which require better collaboration between all stakeholders, but relate to the entire disaster risk management cycle. Cooperation is important in integrating different kinds of knowledge, such as the knowledge and experience of local communities, that of formal and informal institutions, and that of the research, policy and practitioner communities. It also facilitates the development of a common understanding of vulnerability as well as effective measures to reduce it. Cooperation between different stakeholders, and the participation of local communities, also fosters inclusion and joint ownership of decision-making processes.

6.2.4. Strengthen environmental protection and post-disaster rehabilitation

It is now widely acknowledged that the state of the environment is an important component of human well-being and sustainable development (MA, 2005; Jäger et al., 2007). As our understanding of the interactions between human activities and natural processes within coupled human-environment systems improves, the calls for the strengthening of environmental governance and undertaking of post-disaster rehabilitation of affected ecosystems become increasingly louder. Recent research indicates that human vulnerability and livelihood security are closely linked to biodiversity and ecosystem resilience (Adger 2000; Adger et al., 2005; Holling 2001; Folke et al, 2002; MA, 2005). The role of resilient ecosystems in underpinning resilient social systems and therefore decreasing vulnerability to natural hazards is related to the capacity of ecosystems to buffer the impacts of extreme events. Healthy ecosystems are also able to provide more options for communities to assist with livelihoods recovery following a disaster.

In many coastal areas in South and Southeast Asia urbanization and increasing demand for land and natural resources is leading to the degradation and destruction of wetlands, floodplains, forests, and other coastal ecosystems. In some areas much of the natural coastal ecosystems have been replaced by aquaculture or other kinds of commercial development. Increasing competition for these natural resources affects particularly poor and marginalised people who directly depend on these resources for their livelihoods (Jäger et al., 2007). The loss of traditional coastal livelihoods such as fishing and collecting forest products, forces many people to migrate to urban areas to seek employment opportunities there.

The links between ecosystem health and human vulnerability to environmental risks are increasingly understood but are still only poorly addressed in the recommendations for reducing vulnerability to coastal hazards. Most environmental recommendations focused on the creation or rehabilitation of natural barriers to the physical impacts of coastal hazards, such mangrove belts and zones with limited or no development.

6.2.5. Integrate disaster risk reduction into sustainable development strategies

Disasters are increasingly becoming a global challenge for sustainable development (Comfort et al., 1999). There is therefore an urgent need to develop strategies that integrate, much more strongly, disaster risk reduction with natural resource management, poverty reduction and sustainable development (Thomalla et al., 2006).

In the reviewed literature socio-economic development was identified as a major cause of vulnerability to coastal hazards. Many developing countries in South and Southeast Asia are undergoing rapid socio-economic development. For example, in India the shift in economic policies in the1980s from protection and nationalism to liberalization and globalism, to open the Indian economy to world trade, has resulted in high national growth rates. However, accompanying this overall economic growth are increasing poverty and inequalities (Grant and Nijman, 2002). Calgaro (2005) investigated the vulnerability of tourism- dependent communities in Thailand to the 2004 Indian Ocean Tsunami. She found that the growing development of the tourism industry along Thailand's coasts has led to the over- exploitation of natural coastal resources that were previously used in a more sustainable way by the indigenous inhabitants.

Overexploitation and degradation of coastal ecosystems increases the physical exposure to coastal hazards such as tsunamis. This has been demonstrated in Indonesia and Sri Lanka, as well as other areas affected by the tsunami (e.g., Adger et al., 2005) where areas devoid of sand dunes, mangrove forests, and wetlands experienced greater impacts of waves penetrating inland than areas with natural ecosystem barriers. Deforestation for intensive production of mono cash crops or other industries such as shrimp farming and fishing, also reduces the livelihood options available to local communities (Adger et al., 2005). In many coastal locations, environmental degradation and overexploitation of natural resources also reduces the potential for economic recovery after a disaster, because traditional income sources based on coastal ecosystem services are lost. These relationships indicate the importance of developing strategies for sustainable development that incorporate the building of ecological and social resilience to environmental and other shocks and surprises. In this sense, disasters serve as evidence of the need for changes in public policy and practice and create opportunities to redesign, revise or rebuild damaged human environments (Comfort et al., 1999). Without consideration of such opportunities, the vulnerability of human-environment systems in hazard- prone regions is likely to continue to increase.

7. CONCLUSIONS AND OPPORTUNITIES FOR FUTURE WORK

Analysis of the state of scientific understanding of the causes of hazard vulnerabilities and the recommendations put forward by researchers to reduce these vulnerabilities revealed important shortcomings in the relevance of existing scientific research in providing appropriate and relevant information for policy and practice (see also Thomalla et. al, 2006). Gaps exist, in particular, in the application of conceptual thinking in vulnerability assessment, the development of operational methodologies relevant for actors at the sub-national level, and the formulation of concrete recommendations that address the systemic underlying causes of vulnerability. There are also clear mismatches between the factors contributing to vulnerability and the recommendations in addressing the cause and effect relationships, as well as the scale and type of suggested interventions.

7.1. Limited understanding of vulnerability patterns

A wealth of empirical case studies on social vulnerability to multiple risks has been produced at scales ranging from the household to global level. Experience in undertaking such assessments is diverse and the findings are highly context and place specific (Turner et al., 2003). Because the characteristics of different locations can vary considerably, some researchers e.g. Weichselgartner and Bertens, (2000); Cannon et al.,(2003) argue that each disaster situation is unique. Whilst this is true, they confront some general factors which contribute to vulnerability e.g. common hazards or stresses, such as droughts, floods, coastal hazards and famine.. The understanding of the causal structures and dynamics of vulnerability remains, however, patchy and anecdotal despite the advances of vulnerability research during the past two decades (Adger et al., 2005; Kasperson and Dow, 2006). To date, very few rigorous comparative studies that aim to synthesise this dispersed empirical evidence have been

undertaken. Examples are the work of Misselhorn (2005) in the area of food insecurity in Southern Africa and that of Geist (2005), Geist and Lambin (2004) and Lambin and Geist (2004) in the area of land cover change.

Recently, progress has been made in improving integrative analysis of vulnerability and human well-being in the context of environmental risks and change. The UNEP Global Environment Outlook GEO-4 Chapter 7 "Vulnerability of Human-Environment Systems: Challenges and Opportunities" (Jäger et al., 2007) describes a number of "archetypes" of vulnerability that are defined as specific, representative patterns of the interactions between environmental change and human well-being. The archetypes do not describe one specific situation, but rather focus on the most important common properties of a multitude of cases that are "archetypical". By illustrating the basic processes whereby vulnerability is produced, this enables policymakers to recognize their particular situations within a broader context, allowing for important connections between regions and the global context to be identified and generating insights into possible solutions. This approach is inspired by the syndrome approach, which looks at non-sustainable patterns of interaction between people and the environment, and unveils the dynamics behind them (Petschel-Held et al., 1999; Haupt and Müller-Boker, 2005; Lüdeke et al, 2004). The archetype approach is broader, as it includes opportunities offered by the environment to reduce vulnerability and improve human well-being (Jäger et al., 2007).

With regard to coastal hazards, many studies have been undertaken during the last few decades and a considerable number of them focus on Southeast Asia. However, there have been few attempts to investigate comprehensively the underlying factors and pathways through which social vulnerability to coastal hazards is constructed, and this is the first systematic review based on the analysis and comparison of a large number of case studies.

One of the key aims of this analysis was to determine whether typical patterns of vulnerability could be identified in the context of coastal hazards in Southeast Asia. We found that conceptually links between different causes could be established, but that many different interpretations of how these factors interact to produce vulnerability exist, depending on the scale of analysis and the specific environmental, historical, and social contexts of the particular case. More research is therefore required to facilitate the systematic assessment of vulnerability across different sectors and geographical scales.

7.2. The causes of vulnerability: overwhelming focus on exposure

The reviewed documents focused overwhelmingly on physical and social factors influencing hazard exposure. Geographic and environmental factors, particularly climate change, changing rainfall patterns, low-lying coastal land, and sea-level rise, were considered to be the most important factors contributing to vulnerability to coastal hazards (Table 5.8). Table 5.8 shows that many of the most frequently mentioned factors related to socio-economic aspects of vulnerability, particularly demographics. Population growth was the highest ranking single cause contributing to vulnerability. Population density, migration, and the tendency of people to live in hazardous areas were other factors frequently mentioned. Following in importance were factors relating to human conditions and basic rights, such as poverty, lack of access to resources, and inequality. These factors in turn can strongly influence other causes of vulnerability, particularly migration. The capacity to cope with hazards relates predominantly to differences in the level and distribution of poverty, access to natural, economic capital (credit, welfare) and social capital (networks, information, technology, relationships), the quality and effectiveness of governing institutions, as well as factors relating to health and globalization (e.g. Jäger et al., 2007, IPCC, 2001).

7.3. Recommendations ignore the most important underlying causes of vulnerability

Analysis of the recommendations revealed a strong emphasis on issues relating to disaster risk- management activities and little consideration of issues relating to vulnerabilities arising from socio-economic causes (Table 5.15).

Many of the factors considered by the authors of the reviewed documents as most important in creating hazard vulnerability relate to social structures and the underlying political economic processes that determine power relationships between social groups and their access to resources. High levels of poverty and marginalization are closely linked with vulnerability, not just to hazards but to all kinds of environmental and socio-economic shocks and surprises. The extent of poverty, lack of entitlements and resource access, and inequality are important indicators and drivers of vulnerability. Although not the only cause of vulnerability, poverty exacerbates it by driving many other causes of vulnerability, such as migration and population growth in high-risk coastal areas. Addressing these factors requires challenging the structures and relationships of today's societies that perpetuate inequalities and marginalisation.

Rather than using these issues as a starting point for developing strategies for reducing vulnerability, most recommendations are concerned with measures that enhance coping and responses to the hazard event itself, thus they identify proximate rather than underlying causes. Whilst such recommendations make an important contribution to reducing the potential impacts of hazards, they do not address the underlying systemic causes of vulnerability (Figure 7.1). . For example, improving hazard knowledge might help people living or working in exposed coastal areas to prepare for the impacts of potential hazards, but it does not address the reasons why these people have no choice but to live in such areas in the first place.

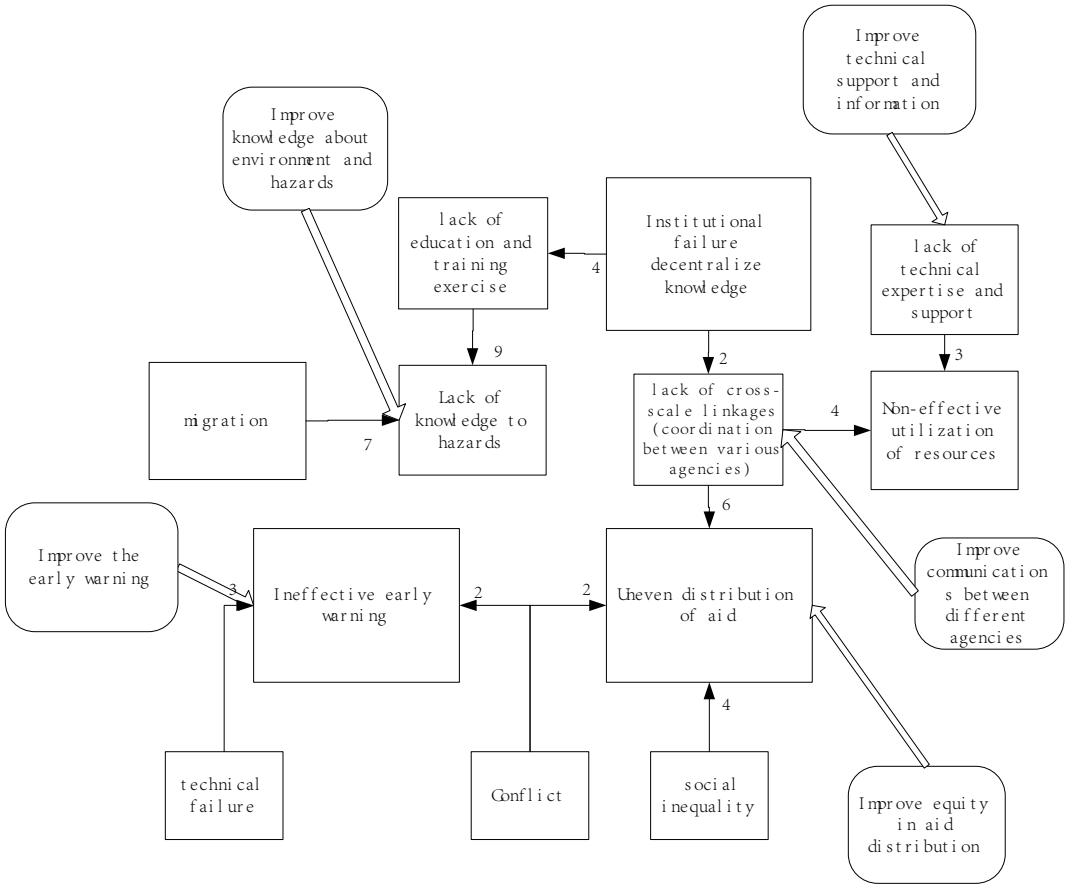

Figure 7. 1 Recommended intervention points to reduce vulnerability to coastal hazards

7.4. Urgent need to improve the integration of science-policy linkages

This synthesis highlights the need for a multi-scaled and multi-disciplined research approach that addresses the gaps between field-based case studies, larger-scale vulnerability assessments, conceptual frameworks and theory, and the implications for policy and practice. Figure 7.2 illustrates an idealised process from science-relevant research to the development of policies and actions to reduce hazard vulnerability. In this process, place-based case studies are undertaken, using a formal conceptual framework and well-defined parameters for assessing vulnerability. The insights from such case studies form the basis for developing recommendations aimed at formulating or improving management strategies and policies for reducing vulnerability. These strategies and policies, taking into account other relevant issues, guide the implementation of disaster risk reduction activities. Such interventions in turn directly affect human activities at multiple levels and scales and influence the conceptual framework and methods for undertaking future research. Currently there appear to be several important gaps in this process:

7.4.1. Lack of primary data and limited substantiation of arguments

The 128 documents analysed included 70 review and general discussion papers, 46 case studies, 12 conceptual and 8 methodological papers. Most of the review papers focused on more general institutional policies or integrated management approaches for water-related hazards. A relatively small number were concerned with concrete aspects of disaster risk reduction or specific practical implementation measures. 93 documents presented research undertaken at scales greater than the national level (global, multi-national and regional), 32 focused on the local level, such as a particular coastal area, an affected city, or a vulnerable district, and 3 reported on work at the community level. In the absence of relevant data and substantiated arguments many documents fail to contribute to our understanding of who is vulnerable and why, and what measures might be most appropriate and effective in reducing hazard vulnerability.

7.4.2. Lack of conceptual frameworks in guiding vulnerability case study analysis

This synthesis highlights the tremendous gap between conceptual and theoretical work on vulnerability, and between experiences, from empirically based case studies as well as practical efforts. The selected documents included a large number of local case studies of coastal hazard vulnerability but few of these employed conceptual or theoretical frameworks of vulnerability to guide the analysis. Whilst references to ten different conceptual frameworks were identified in the literature, all of the documents in which they were mentioned focused either on a general theoretical discussion of hazard vulnerability (mostly on a global scale), or on a discussion of the concepts and theoretical underpinnings of vulnerability research. Since the purpose of undertaking a case study is to obtain a detailed understanding of the factors contributing to the vulnerability of local individuals, households or communities, in order to identify potential entry points for policy intervention, the use of a conceptual framework is important to help to identify all possible factors contributing to vulnerability and to map the interactions between them. There are very few links in the literature between theoretical thinking and the context-specific richness of experience and knowledge derived from local case studies.

7.4.3. Limited relevance of recommendations at sub-national scales

The links between vulnerability assessment and policy development are extremely weak, as most of the assessments are undertaken at national, regional and global levels and have limited relevance to decision-makers at sub-national scales. Ineffective communication between different stakeholders relating to all phases of the disaster risk reduction cycle was identified as one of the main factors contributing to vulnerability. Whilst many authors demonstrate the need to improve information sharing between different actors, to increase hazard awareness amongst the public, and to improve the dissemination and communication of early warnings, most recommendations are so general that they are of limited value in formulating appropriate and effective disaster risk reduction strategies and policies.

They frequently take the form of statements such as the"need to reduce poverty" or "need to develop community-based recovery strategies", without providing concrete suggestions as to how such measures could be realized in the context of practical operational activities.

7.4.4. Need to consider different perceptions of risks and vulnerabilities

Many existing and recommended disaster risk reduction strategies do not take into account the perceptions and situations of people at risk from coastal hazards. Even though many measures to help people to build their capacity to cope with hazards exist, they are frequently not effective because they do not address the realities people face in their everyday lives. There are many examples in the selected literature e.g., Haque and Blair, (1992; Atmanand, (2003); Thomalla and Schmuck, (2004)) that show that for religious reasons some people prefer to seek shelter in temples or other religious places, rather than formal shelters built by government authorities. In other cases e.g., Bandyopadhyay (1997), efforts to evacuate from high risk areas fail, because people fear losing their assets while they are away from their home.

7.4.5. Need for better communication through formalization

Ineffective communication between different stakeholders, relating to all phases of the disaster risk reduction cycle, was identified as one of the main factors contributing to coastal hazard vulnerability. Many of the reviewed documents identified the need to improve information sharing between different actors, increase hazard awareness amongst the public, and improve the dissemination and communication of early warnings. However, most recommendations for reducing vulnerability identified in

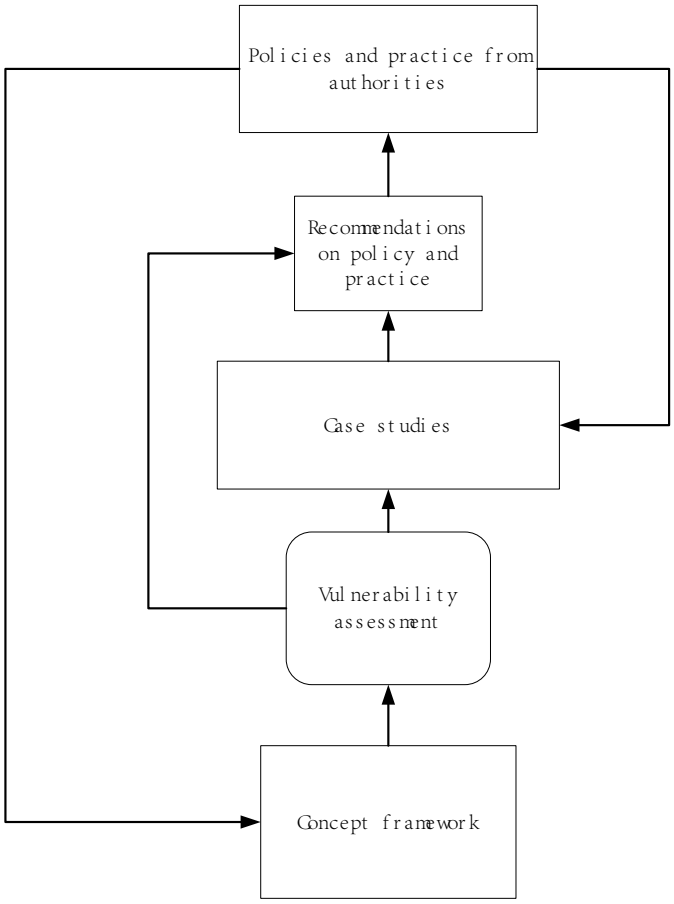

Figure 7. 2 Ideal process from research to the development of policies and actions to reduce hazard vulnerability

the selected literature were so general that they were of limited value to decision-makers, policymakers and practitioners in formulating appropriate and effective disaster risk reduction strategies, policies and operational activities. The tendency to focus on information sharing and public awareness raising is also based on a flawed assumption that increased awareness will result in a better response. Many conditions of vulnerability are severely curtailed by limited livelihood and behavioural choices, so improved awareness may not necessarily allow for better responses, as people face a limited range of options for change.

There is a need to improve and apply methods to assess vulnerability and to produce policy-relevant findings that better inform disaster risk reduction. Whilst the concept of vulnerability is widely used amongst researchers, policymakers and practitioners, it is rarely defined or applied. The "notion" of vulnerability needs to be formalized in order to support accurate communication within and between different communities, and to eliminate misunderstandings through the use of ambiguous terminology (Hinkel and Klein, 2006; Ionescu et al., 2006). Building on the GEO-4 archetype approach (Jäger et al., 2007), current collaborative work between the Stockholm Environment Institute (SEI), the Potsdam Institute for Climate Impact Research (PIK), and the Netherlands Environmental Assessment Agency (MNP) focuses on developing a methodology for formalising research approaches that better describe and quantify typical patterns of vulnerability of human-environment systems to multiple stresses.

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