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Socio-Economic Aspects of Disaster's Impact: An Assessment of Databases and Methodologies

by

Suman K SHARMA

Economic Growth Centre
Division of Economics
School of Humanities and Social Sciences
Nanyang Technological University
14 Nanyang Drive
SINGAPORE 637332

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An Assessment of Databases and Methodologies

Working Paper

Suman K Sharma, Ph.D.[*]

Visiting Research Scholar at Economic Growth Centre
Division of Economics
School of Humanities and Social Sciences

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[*] Division of Economics, School of Humanities and Social Sciences, Nanyang Technological University, HSS 04-53, 14 Nanyang Drive, Singapore 637332; Tel: +65 6513 8123 (off); +65 9626 1543 (cell); E-mail: SumanSharma@ntu.edu.sg; 2suman.sharma@gmail.com

ABSTRACT

Economists and social scientists have for the most part not considered disaster issues as a priority. This has changed in recent years as researchers have been analyzing disasters quantitatively in an effort to understand their social, economic and political dimensions. Consequently, there seems to be an ever growing demand for data and information as well as a sound set of methodologies so as to facilitate a thorough investigation of disasters' impact on national development.

The present study provides an assessment of existing methodologies of estimating socio-economic aspects of disaster impacts and the availability and adequacy of existing data on disaster events. The study methodology involves three major activities, review of literature, assessment of existing databases and methodologies, and examination of case studies of recent disasters in Southeast Asia. As reviewed in the paper, major impediments to analyzing disaster impact in the Southeast Asian countries are issues related to data collection and estimation methodologies, complex nature of disaster impact, inadequate national capacity to undertake impact assessments and high frequency of natural disasters. Despite the exploratory nature of this study, issues raised here indicate the precarious situation of hazards and disaster risks in this region thus justifying additional work in this area.

The key data issues that complicate the task of disaster impact estimation include data inadequacy, data inconsistency, variations in terminologies used in relation to data attributes and the resulting difficulties in identifying disasters and their effects. The existing methodologies available for estimating disaster impacts face several issues due to the complex nature of impact assessment. Economic models that are used in disaster impact assessment were not designed specifically for disaster analysis and many for the most part do not account for disruptions in economic relationships as a result of disasters. Additionally, following a disaster event, several other factors might come to play. Consequently, these general purpose models fail to handle the abruptness and largely unpredictable situation during a disaster event. In light of these findings the paper recommends areas for further investigation with focus on Southeast Asia.

JEL Codes: O1, O40, Q54

Key words: Economic Development, Economic Growth, Natural Disasters

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1. Introduction

Economists and social scientists have for the most part not considered disaster issues as a priority till recently. This has changed in recent years as researchers have been analyzing disasters in an effort to understand their social, economic and political dimensions. One area of research, especially among economists, is the quantification of disasters' impacts on nations' development (Albala-Bertrand 1993; Rasmussen 2004; Toy and Skidmore 2007; Raddatz 2007; Noy 2009; and others).

Quantification of disaster impacts has gained interest among economists also in the light of recent evidences from countries around the world that appear to indicate a rising frequency and severity of disaster events as manifested in increased losses on all fronts – economic damage, human suffering and injuries. The increased losses have the potential to negatively impact the long-term development of a country, more so in developing countries, for which disaster losses expressed as percentages of the national GDP can be much higher compared to developed countries. Studies also show that on average Asian countries suffer more loss in human lives and property damage compared to most countries in other regions due to a combination of factors such as higher population density, rapid urbanization, inadequate infrastructure growth and a seemingly higher number of incidents of natural hazards (World Bank 2007; Noy 2009; UNESCAP 2008).[1] This trend is likely to continue given the observed demographic shifts to more vulnerable areas, namely, coastal areas subjected to typhoons and floods; increase in national wealth; and the potential impact of global climate change on weather events (DfID/ODI 2005; Ghesquiere and Mahul 2007; IPCC 2007).

Asia's greater vulnerability to natural disaster was evident in 2008 as well when the Asian countries reported nine of the top ten disaster-related deaths. In 2008, the two events reporting the largest number of fatalities were Cyclone Nargis in Myanmar with more than 100,000 fatalities and the Wenchuan Earthquake in China with about 80,000 fatalities plus missing people. In addition to the fatalities, the Wenchuan Earthquake alone caused an estimated economic damage of about US$120 billion. Countries reporting the largest

[1] Disasters in South-Asia, Southeast Asia and East Asia are also more costly - both in terms of loss in human lives and property damage – compared to those in the Middle East and Latin America. Island-nations appear more vulnerable to disasters in terms of lives lost, number of people affected and property damage, which on average are twice as large as in any other region (World Bank 2007; Noy 2009; UN-ESCAP 2008).

number of natural disasters in 2008 were China, the US, the Philippines and Indonesia. As in 2007, 2008 also saw large numbers of people affected by a few natural disasters. For instance, a total of 122 million people were affected by earthquake and severe winter conditions in China while 12 million were affected by droughts in Asia as a whole (Rodriguez et al. 2009).

In 2009, the single disaster event that caused the highest death toll globally was the September earthquake in Indonesia with 1,100 fatalities, followed by a series of typhoons and their associated floods in the Philippines and Taiwan. In terms of the absolute number of people killed as a result of disasters throughout 2009, India ranked the highest with 1,733 fatalities followed by Indonesia and the Philippines with 1,466 and 1,362 fatalities, respectively. Similarly, in terms of economic impact of disasters (in absolute amount), out of the 10 most affected countries in 2009 four were from Asia, namely, China, Indonesia, Japan and Viet Nam. While in terms of absolute number of people affected by disaster events in 2009, seven of the top 10 countries were in Asia. All of the indicators make Asia once again the most disaster affected continent in 2009 (CRED 2010).

Table 1.1 shows the trend in average annual damage caused by natural and technological disasters in five Southeast Asian countries during 1970-2008[2]. The figures presented indicate an overall increase in the average annual damage of disaster over the decades. Table 1.1 does not include disaster damage in 2009, during which Indonesia and the Philippines in particular sustained high losses. The 2009 West Sumatra Earthquake in Indonesia caused an estimated damage amounting to US$ 2.3 billion (BAPPENAS 2009) while two powerful typhoons, Ketsana and Parma, in 2009 hit the Philippines causing an estimated damage of about US$ 4.4 billion (PRC, Phillipines 2009).

Table 1.1: Average Annual Damage Costs of Natural and Technological Disasters in Southeast Asia, 1970-2008 (in 1000 US$)

Period	Indonesia	Philippines	Malaysia	Thailand	Singapore
1970-1979	29,075	120,256	3,700	44,500	0
1980-1989	43,289	166,363	1,236	110,965	0
1990-1999	1,064,695	328,732	37,300	290,559	614
2000-2008	1,132,527	139,719	166,778	233,847	0

Source: "EM-DAT: The OFDA/CRED International Disaster Database www.emdat.be - Université Catholique de Louvain - Brussels -Belgium" (created on 23 June 2009)

[2] The abrupt increases in the figures between 1980-1989 and 1990-1999 could be partly due to underreporting in earlier years of data collection and better reporting in later years.

Table 1.2: Natural and Technological Disasters in Southeast Asia, 2000-2008

Country	No. Events	Total no. killed	Total no. affected	Total damage costs (in 1000 US$)	Average Annual Damage Costs (in 1000 US$)
Indonesia	228	182,187	8,889,256	10,192,743	1,132,527
Malaysia	35	349	450,398	1,501,000	166,778
Philippines	163	10,331	36,877,460	1,257,474	139,719
Singapore	2	35	2,227	0	0
Thailand	79	9,929	28,021,797	2,104,624	233,847
Grand Total	507	202,831	74,241,138	15,055,841	1,672,871

Source: "EM-DAT: The OFDA/CRED International Disaster Database www.emdat.be - Université Catholique de Louvain - Brussels -Belgium" (created on 23 June 2009)

Within Southeast Asia, Indonesia and the Philippines are particularly prone to natural disasters as indicated by the map in Annex 2. As shown in Table 1.1, in terms of average annual damage caused by the natural and technological disasters, Indonesia and the Philippines are the two most affected countries in Southeast Asia. Table 1.2 shows additional indicators of the magnitude of natural and technological disasters in five countries in Southeast Asia during 2000-2008. The figures indicate that Indonesia and the Philippines tend to suffer the most in terms of frequency of disasters, number of people killed and number of people affected by disasters. When the figures for 2009 are included, these two countries suffered the most in terms of all the available indicators including the cost of physical damage.[3]

The growing incidences of disasters and the observed trend in increasing disaster losses and the possibility of rising losses in future resulting from climate change have generated an increasing interest among economists and social scientists in disaster analysis, particularly in examining disaster issues and their impacts on a nation's development and peoples' lives. However, despite an increasing amount of research in this area, economists and social scientists appear to have conflicting views on the exact nature of disasters' impact on a nation's socio-economic development. The existing empirical literature indicates that the interrelationship between development and disasters is not straightforward as natural disasters' impact on a nation's growth in many instances remains inconclusive (Albala-Bertrand 1993; ECLAC 1999; Benson and Clay 2004; Raschky 2008; DfID/ODI 2005; Cuaresma et al. 2008; Okuyama 2003; Asgary et al. 2006).

In recent times there seems to be a growing awareness of the multi-faceted impacts of disasters and that simple statements of disasters' impact on nations' development cannot be made without considering their full impact and the interrelationships among various factors. Consequently, the increasing disaster events and the associated damages have led

[3] Section 5 of this paper presents case studies of the 2009 West Sumatra Earthquake in Indonesia and the 2009 Typhoons Ketsana and Parma in the Philippines.

to an ever growing demand for data as well as a sound set of methodologies so as to facilitate a thorough investigation of disasters' impact on development of a nation. Furthermore, government policymakers are increasingly demanding quantitative information to justify resource allocations to undertake assessments of risks and vulnerabilities associated with disasters, and design mitigation and preparedness measures.

The present study provides an assessment of existing methodologies of estimating socio-economic aspects of disaster impacts and the availability, adequacy and completeness of existing data on disaster events and their effects in the context of developing countries. The overall objective of the study is to examine the availability, adequacy and relevance of existing databases and methodologies for estimating the socio-economic aspects of disasters' impact focusing at the national level[4].

The objective will be achieved through the following specific tasks:

i. identify available databases on disaster incidents and disaster effects;
ii. identify available methodologies for assessing social and economic aspects of disaster impacts;
iii. determine the relevance and adequacy of the existing databases and methodologies to undertake an impact assessment; and
iv. recommend potential areas for further investigation.

The study methodology involves three major activities, review of literature, assessment of existing databases and methodologies, and examination of case studies of recent disasters in Southeast Asia. Existing disaster databases in public and private domain are identified and reviewed. A similar effort is made through undertaking an extensive review of existing methodologies for assessing disasters' impact on a nation's development. The available methodologies are assessed and their respective issues in relation to disaster impact estimation are highlighted. In addition, a brief introduction to disaster situation and trend in a few Southeast Asian countries has been provided and three recent disasters in Indonesia and the Philippines are described to show an application of one of the methodologies for assessing disaster impact.

This paper is based on an exploratory research and therefore a thorough impact analysis of disasters is beyond its scope. However, issues raised here and the case studies will show the precarious situation of risks related to hazards and disasters in this region thus justifying additional work in this area.

[4] Most of the economic literature on disasters deals with natural disasters and thus for simplicity, the term 'disaster' used in this paper refers to 'natural disaster' unless stated otherwise. Although discussions presented here are mostly limited to impact estimation of natural disasters, the data and methodological issues raised can be generalized to impact estimation in the context of man-made disasters as well (Pelling et al. 2002; UN-ECLAC/WB 2003; Raddatz 2007).

The paper is divided into six sections. Apart from this introductory section, Section 2 outlines the conceptual framework followed in this paper. Section 3 reviews the existing databases and methodologies commonly used to estimate disaster impacts. Section 4 elaborates the underlying issues on disaster impact estimation focusing on data issues and methodological issues. Section 5 provides a brief introduction to disaster situation and trend in a few Southeast Asian countries including review of three recent natural disasters in Indonesia and the Philippines. Section 6 provides concluding remarks and recommends areas for further investigation.

2. Concept

A growing number of economists and social scientists have, in recent years, examined the socio-economic aspects of disasters but the approaches they have taken are geared more towards examining disaster issues empirically and providing empirical modelling frameworks for disaster analysis rather than dealing with the theoretical aspects of economics of disasters (Albala-Bertrand 1993; Noy 2009). Okuyama (2003) believes that this is not surprising as disaster events are indeed quite different from other economic events in terms of their frequency, extent and predictability; possibly not providing sufficient observations to construct a unique theoretical framework. In order to set the context for the present paper, this section outlines a theoretical framework on disaster impact that is largely in line with the current thinking on disaster risk management (DRM) framework (GTZ 2002; Hochrainer 2009).

The natural disaster risk, under the DRM framework, is seen as a function of three components – hazard, exposure of assets and their vulnerability (Hochrainer 2009). As shown in Fig. 1.1, a hazard is an event that has potential for causing harm or loss by impacting an exposure that is characterized by a certain vulnerability. Hazard analysis thus involves determining the type of hazards affecting a certain area with specific intensity and recurrence (ISDR 2001; Benson and Clay 2004; Hochrainer 2009). In the existing literature, the two terms, hazard and disaster, are sometimes used interchangeably, but it is important to distinguish between the two; as a disaster is an outcome of a hazard impacting on the vulnerability of a society or nation (Ariyabandu 2001). An assessment of exposure at risk can be undertaken only through examining the relevant population/assets, etc. that are exposed to certain hazards in certain areas. The potential of these exposures to suffer harm or loss is defined as vulnerability, which is typically expressed in terms of damageability in case of physical assets and resilience (or lack thereof) in case of non-physical assets. Hazard analysis is technical in nature and is conducted by relevant domain experts but disaster analysis on the other hand, requires a more inter-disciplinary approach as the impacts go beyond physical damage to the affected exposure.

Impacts from disasters are typically classified into direct and indirect impacts. Direct impacts include damages on human and physical capital while indirect impacts include effects on flows of economic activity, for instance, changes in output structure – construction and agriculture, loss in employment, income and consumption. A multitude of factors - physical, socio-economic, political and institutional - interact with natural disasters' direct and indirect impacts, in a complex manner to determine the ultimate effect on a nation's economic growth and other socio-economic variables (Benson and Clay 2004; Royal Society 1992; Rodriguez et al. 2006; Handmer and Dovers 2007; Raschky 2008) (see Fig. 1.1). The interactions among physical losses and human losses and their resulting impact on myriads of socio-economic factors (some of which are listed in Fig. 1.1) complicate the task of estimating their impacts on national economies (Loayza et al. 2009).

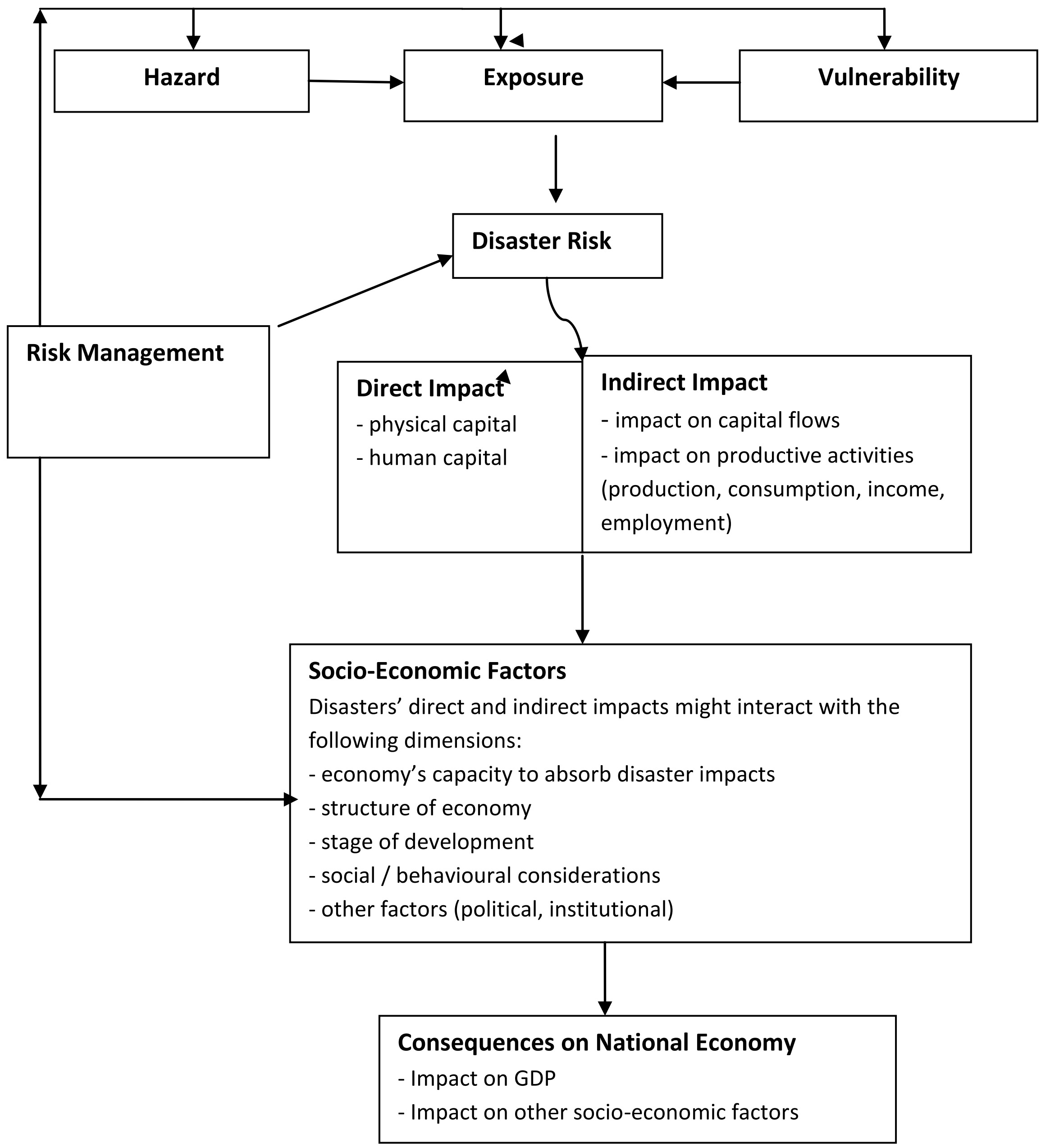

Fig. 1.1: Conceptual Framework for explaining economic risk due to natural disasters (adapted from GTZ 2002; Hochrainer 2009)

In the literature on disaster, the terms damage and losses, sometimes are used interchangeably but the recent trend is to define damage as damage to stocks (physical and human capital) while losses include the resulting flows of economic activities. The damages caused by disasters resulting from physical destruction are measured by physical indicators, such as the numbers of buildings/physical infrastructure destroyed, injuries and deaths (The National Academics 1999). In economic terms, therefore, damage refers to damage on stocks (physical capital and human capital). These damages could lead to losses from interruptions of economic activities, such as production and/or consumption. In more recent literature, these flow impacts are commonly known as the first-order losses of a disaster. The first-order losses, in turn, can lead to higher-order effects, which refer to the system-wide impact of flow losses through interindustry relationships[5]. Rose (2004) and Okuyama (2007) cite an example where a power company gets destroyed by an earthquake resulting in an interruption in electricity production for a certain time period. The production loss is the loss occurred to the power company while another firm although not damaged by the earthquake could still face severe business interruption due to lack of power supply. In this sense, the disruption of the latter firm is known as the indirect (flow) effects[6]. Consequently, total (flow) impacts of a disaster include first-order and higher-order effects. Recent literature has increasingly emphasized the need for estimating higher-order effects for a number of reasons such as to understand vulnerability on the part of communities and individuals, evaluate mitigation measures, determine appropriate levels of disaster assistance as well as recovery measures, and to inform insurers of their potential liability (Rose 2004).

A growing number of empirical studies have started examining the linkage between disaster risk – direct and indirect – and economic growth using macroeconomic growth theory[7]. These studies are usually based on a common understanding that the short-term consequences of a disaster on an economy can be explained in terms of its direct impact on the existing capital stock (Popp 2006; Baritto 2008; Clower 2005)[8]. An assessment of the

[5] The use of the term 'higher-order effects' also helps ease the confusion with the terminology used in economic models particularly in case of the Input-Output models (Rose 2004; Okuyama and Sahin 2009).

[6] Disaster researchers have defined various types of indirect losses, which include short-term losses like induced losses in sales, wages and/or profits; input-output losses to firms include forward-linked or backward-linked in production to businesses closed as a result of direct physical damage; and decline in spending losses triggered by firm closures or cutbacks – multiplier or ripple effects. Similarly, short-term gains include changes in future production, employment and income and/or changes in these flows outside the damaged area; income gains outside the impact area to owners of commodities inflated in price by disaster induced shortages and positive economic shock by increased production, employment generated from reconstruction activities (Okuyama and Sahin 2009).

[7] Recent examples of macroeconomic growth theory approach include Noy (2009); Loayza et al. (2009); Baritto (2008); Noy and Nualsri (2009) and Hochrainer (2009).

[8] In many instances, the Solow-Swan growth model is adapted in order to examine the channels through which natural disasters could affect economic growth. This model is flexible as it is conceptually strong, and also, able to clearly describe the process that occurs in the transition to a long-run steady state. Based on a simple Cobb-Douglas production function, combined with a few standard assumptions (such as dynamism and diminishing

disruption caused by a disaster on the capital stock, if any, will, therefore, help understand the output effect of the disaster during the short-run. The role of physical capital stock, in addition to labor and technology, as a determinant of economic growth has been acknowledged for a long time. The more recent literature has extended the concept through incorporating human capital and the substitutability between two; and this is precisely the concept mostly seen to explain the disaster impact on an economy (Baritto 2008; Popp 2006; Clower 2005)[9].

Review of literature shows the lack of uniformity in terminologies used in disaster research for hazard, disaster, losses, and damage. This situation is partly the result of researchers in different disciplines using terms specific to their respective disciplines. This lack of uniformity is reflected in the various disaster databases making it difficult to undertake an empirical analysis on disaster impact. Perhaps because of this and the complexity of disaster consequences a theoretical framework applicable to all disaster events and nations is proving difficult to develop.

3. Disaster Impact Estimation: Existing Databases and Methodologies

3.1 Existing Disaster Databases

A fundamental requirement in understanding and interpreting the economic and social dimensions of disaster impacts is data availability on disaster events and their effects. Attempts have been made at the international, regional and national levels to systematically collect data and information on frequency and impacts of disaster events. This section briefly describes the available disaster databases.

EM-DAT Database

The Centre for Research on the Epidemiology of Disasters (CRED) has been regularly maintaining a disaster database, known as CRED Emergency Events Database (EM-DAT) at the University Catholique de Louvain in Brussels, Belgium. The EM-DAT database is intended to be used to assist in the provision of humanitarian aid, particularly on the part of international bodies so as to determine the threshold level above which aid becomes necessary. CRED EM-DAT database contains information on disasters since 1900 to present of about 12,000 disaster events around the world. In order for a disaster event to be included into the EM-DAT database, at least one of the following criteria should be met: i) the event causes death of 10 or more people, or ii) at least 100 people are reported to be

marginal product of each factor), it is shown that the growth rate of output goes hand-in-hand with the capital growth rate. Loayza et al. (2009) identify three major channels through which natural disasters could affect transitional growth, namely, total factor productivity (TFP), the supply of materials and intermediate inputs, and the relative endowment of capital and labor.

[9] A companion paper by the author titled 'Review of Economic Literature on Implications of Disasters on Development' provides an extensive review of available empirical literature examining how natural disaster events – through their possible interaction with social, economic and institutional aspects of an economy-affect a nation's growth .

affected by the event, or iii) a state of emergency has been declared in the aftermath of disaster, or iv) there has been a call for international assistance. The dataset provides information on the location of the disaster, the total number of people killed, the total number of people affected and the total damages (expressed in US dollars). The EM-DAT database is available to the public.[10] Although the available information mostly represents direct effects and does not reveal the full scale of disaster impacts, these are nevertheless useful as they provide the foundation for modelling projected future losses (Tschoegl 2006).

NatCat Database

NatCat is a private international level disaster database maintained by Munich Reinsurance Company (Munich Re) and includes data from 1970 to the present on natural disasters. A disaster event would be included into the NatCat database provided that there has been any property damage and/or any person sincerely affected (injured or dead) as a consequence of the event. Disaster events are included on a country and event level with information on number of people killed/injured/affected, economic losses, insured losses and relevant scientific information of the event (wind speed, magnitude and geocoding). Although the database is able to provide more information on detailed economic losses caused by disasters, due to its focus on calculating insured losses, it does not provide adequate data for those areas with lower insurance coverage. The NatCat database is partially available to the public.

Sigma Database

Swiss Reinsurance Company (Swiss Re) is another private institution, which maintains an international level Sigma database on natural and manmade disasters. In order for a disaster event to be included in the Sigma database, the following criteria need to be fulfilled: causes 20 or more deaths and/or 50 or more are injured and/or 2000 or more are made homeless and/or total losses exceed US$70 million. Disasters are recorded on an event entry basis including information on dead, missing, injured and homeless, along with detailed accounting of insured and uninsured damages. Both the organizations, Munich Re and Swiss Re, are credited with several publications on disaster related issues including comparison of disaster events with key economic indicators, all of which provide valuable sources of information (Tschoegl 2006).

Disaster Database Project

Similarly, the University of Richmond maintains the Disaster Database Project, which is an international database (created by Dr Walter Green III) with more than 1800 entries on natural disasters, conflict-based disasters, and human system failures. The database uses a

[10] The IFRC (International Federation of Red Cross and Red Crescent Societies) publishes the World Disaster Report (WDR) annually. The WDR provides a thorough review of global disasters, which has the same focus as the EM-DAT on humanitarian impacts of disasters.

five-phase structure to help describe the nature of the event including an event's impacts, response and recovery. Annex 1 provides further details on the four major international databases discussed above.

Regional Databases

Two regional databases are available on disaster incidents. The Asian Disaster Reduction Centre (ADRC) maintains a database of Disaster Information for Member Countries, which provides information about natural disasters, beginning from 1998, in Asia and Southeast Asia. The ADRC maintained database is easily searchable by date, disaster type, country and GLIDE (Global IDEntifier) number. The GLIDE project, based on a GLIDE number (a universal ID unique to a particular hazard event), is supported by many notable disaster institutions, to address issues in locating disaster data.[11] In addition, the ADRC maintained database lists disaster events in chronological order and where available, provides description of a disaster event including information on human and economic losses.[12]

Similarly, for Latin American countries, the Network for Social Studies on Disaster Prevention in Latin America (LA Red) developed the DesInventar system in 1994, which now maintains 16 national-level databases on natural and technological disasters in Latin America (Tschoegl 2006). DisInventar database was initially built using a combination of disaster databases on the Latin American countries. One of the significant features of this database is that it seeks to associate various spatial scales so as to examine the specific nature of disaster impacts on each community affected (ISDR 2002). The database is now used as the reference database in Latin America not only for disaster related research but also for identifying necessary preparedness and mitigation measures.

Other Sources of Disaster Information

In addition, several national level databases on disaster events maintained by developed and developing countries exist. Also, there are a number of disaster event databases, which cover events like earthquake, floods, technological disaster and biological disaster (Tschoegl 2006).

Similarly, information on disaster impacts including their socio-economic aspects has been made available through several case studies both at the country and regional levels. One major source of information on direct and indirect impacts can be found in the publications

[11] The GLIDE concept is designed to enable data and information related to a particular disaster event to be referenced with a unique ID code. A GLIDE number is comprised of two letters identifying the disaster type, the year of the disaster, a six-digit sequential disaster number, and a three-letter ISO code to identify the country of occurrence. After the number is assigned to an event, it is included in all data documenting the disaster. This allows all data associated with a particular event to be linked to one number (Beckman 2009).

[12] At the Asian Conference on Disaster Reduction in 2003, it was generally recognized that the GLIDE concept as a shared standard was sound, which in light of implementation of the GLIDE scheme itself combined with fundamental issues of reliability and accessibility of disaster data in general, needed further refinement for wider acceptance (Background Note, Asian Conference on Disaster Reduction 2003, 5th ADRC International Meeting, 2003).

by the UN-ECLAC, which has been studying the impact of disasters in Latin America since 1972. The ECLAC studies not only quantify the direct losses from disasters but also examine their macroeconomic implications (see for example, UN-ECLAC 1999). Similarly, the ODI (Overseas Development Institute), the World Bank's Disaster Management Facility and the UNDP have conducted several country studies on natural disasters focusing on disasters' impacts on various sectors of an economy, and the significance of government policy in addressing those (UNDP 2004; World Bank 2007).[13]

The Center for Hazards Risk Research at the Columbia University maintains a project, commonly known as the Hotspots project, which was designed to identify 'hotspot' areas where the natural disaster risk is particularly high. The project assesses the risk of mortality and economic loss on a global grid thus allowing for risk analysis at the sub-national level by calculating risk for each grid cell instead of each country. The project develops three indices of disaster risk, which include the mortality risks assessed for the global, gridded population; the total economic loss risk, assessed for global, gridded GDP per unit area; and the risk of economic loss expressed as a proportion of the GDP per unit area for each grid cell. The Hotspots webpage provides many useful resources and case studies on major events of natural disasters (Beckman 2009).

3.2 Existing Methodologies to estimate disaster impact

One of the most commonly used methodologies for estimating disaster's impact is the ECLAC methodology pioneered by the United Nations. The ECLAC methodology is an over-encompassing approach covering estimations of damage, losses and their sectoral and cross-sectoral impacts. Other approaches that researchers have taken include the use of economic and econometric models. The latter type of models is favoured by economists and social scientists in estimating disasters' impact and their interactions with various socio-economic dimensions of a country. These models are sometimes used to address specific concerns such as estimating the impact of a disaster on a nation's GDP. The models have also been used to estimate the diversity of disaster's impacts, for instance, the input-output modelling framework has proven to be useful in estimating the impacts on a range of sectors and activities of an economy.

3.2.1 ECLAC Methodology

The United Nations developed and outlined a concept on an assessment methodology of disaster in the late 70s (UNDRO 1979, cited in UN-ECLAC/WB 2003). This methodology was further developed and broadened by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC) in 1991 with the goal of estimating not only the natural disaster impacts but also the man-made ones such as armed-conflicts (UN-ECLAC/WB 2003). The methodology was later extended to cover a number of social and

[13] In addition, these studies examine the inherent difficulties in analyzing the economy-wide flow impacts from disasters with focus on the challenges involved in isolating the disaster impacts from other factors.

economic sectors including the environmental damages resulting in the publication of a Handbook in 2003 (UN-ECLAC/WB 2003).

Box 1: ECLAC Methodology

As per the ECLAC methodology, the concepts of damage, losses, and economic and social impacts are defined as follows:

• *Damage* (direct impact) refers to the impact—valued at agreed replacement (not reconstruction) unit prices—on assets, stock (including final goods, goods in process, raw materials, materials, and spare parts), and property. The assessment considers the level of damage in terms of whether an asset can be rehabilitated or repaired or if the asset has been destroyed completely.

• *Losses* (indirect impact) refer to flows that will be affected, such as production declines, reduced incomes, and increased expenditures, over a time period until the economy and assets are recovered. The estimates are quantified at present value.

• *Economic and social impacts* include macroeconomic impacts, poverty impacts, employment and livelihoods impacts, and social impacts. The analysis aims to measure these impacts at the national and sub-national levels.

The impact estimation methodology covers a range of sectors, as well as a few cross-sectoral areas. The commonly assessed sectors are: (i) productive sectors consisting of agriculture and enterprises (industry, commerce, and tourism); (ii) social sectors consisting of housing, education, cultural heritage, and health; and (iii) infrastructure consisting of power, water and sanitation, flood control, transportation and telecommunications. The cross-sectoral areas of assessment normally include disasters' impacts on governance, environment, financial sector, psychological health, employment and income.

Source: UN-ECLAC/WB 2003.

Based on the ECLAC methodology, disasters' impact can be broadly categorized into 'direct' impact and 'indirect' impact. Direct impact[14] includes damages to physical assets, human capital and infrastructure while indirect impacts are associated with changes in the 'flows' of economic activity reflected in, say, loss of productive activities after a disaster occurs[15]. The combined effects of these two impacts may lead to subsequent imbalances in macroeconomic variables of a nation. Also known as secondary effects, these, in turn, may affect government revenues and expenditures, balance of payments and ultimately economic growth, employment and income distribution.

In order to estimate direct Impacts, different assets and stocks directly affected by disaster in both the private and public sector must be identified and valued through surveys and

[14] Catastrophe models have existed since the late 1980s for estimating the direct physical losses from natural disasters for the insurance industry. But these models are not reviewed here for the reason that these models, more commonly known as CAT models, are currently being used for estimating insured losses primarily to properties, and do not normally account for indirect losses.

[15] Some disagreements exist as to the coverage of indirect effects of disasters. The present study follows a largely accepted definition based on which indirect costs of disasters include the loss of business activity due to reduced activities at damaged firms, loss of income in secondary and tertiary employment and business disruptions not directly attributable to damage (Clower 2005).

field assessments using appropriate valuation methods. Estimation of indirect impacts may not be straightforward as they involve dynamic flows of effects that occur over time and are caused by the direct impacts of a disaster. Direct and Indirect effects, in turn, may result in macro-economic imbalances which may include changes in major economic variables such as GDP, gross investment, exports, imports, public expenditure, tax revenues, inflation, unemployment and poverty.

The extended ECLAC methodology recommends estimating sectoral as well as cross-sectoral impacts of disasters. As for the sectoral assessments, first, the sectors have to be identified that are affected by a disaster. For instance, disasters can influence social sectors (education, culture, health, housing), infrastructure sectors (energy, drinking water and sanitation, transportation, communication) and economic sectors (agriculture, trade, industry, tourism). In addition, by classifying the damage in each sector into public and private sector, it is emphasized that the disaster impacts in each sector be estimated by comparing the situation that develops after the disaster with the situation that would have occurred without the disaster, i.e., 'with disaster' and 'without disaster' situation. This requires the need for data and information collection on each sector before the disaster event, including forecasts of how the sector was likely to have developed if the disaster had not occurred (UN-ECLAC/WB 2003).

Similarly, estimating the cross-sectoral impacts is crucial as they involve several cross-cutting issues relevant in the present development context such as those on environment, employment and income, psychological impacts and impacts on governance and financial sectors along with differential impact on women and marginalized groups (UN-ECLAC/WB 2003). Finally, an overall impact assessment is recommended. In order to facilitate the ECLAC approach of disaster impact, in 2005, the Australian Agency for International Development (AusAID) developed some standard guidelines and the corresponding Economic Assessment Tools thus providing direction on disaster impact assessments. The ECLAC methodology and the AusAID guidelines – primarily based on the ECLAC methodology – are now universally accepted in estimating the socio-economic and environmental aspects of disaster impacts, and therefore, widely being used by a growing body of research that has emerged in recent years (UN-ECLAC/WB 2003; AusAid/USP/SOPAC 2005).

The ECLAC methodology standardizes the assessment of damages and losses of a disaster. This greatly facilitates the task of comparing disaster impacts across various disasters and also provides valuable information and tools essential for disaster mitigation, preparedness and vulnerability analysis of economies based on a common framework.

3.2.2 Econometric Models[16]

[16] For simplicity, these models in the present context include macroeconomic models and statistical models.

Various econometric models have been used to estimate indirect and macroeconomic effects of disasters. These models normally use a variety of methods including regression techniques to model a disaster shock as an intrusion on a series of data (Noy 2009 and others), before-and-after statistical analysis (Albala-Bertrand 1993), and country case studies (Benson and Clay 2004). While some of the models rely on a multicountry framework (Albala-Bertrand 1993; Raddatz 2007; Noy 2009; Raschky 2008), and standard growth models (for example, Okuyama 2003 uses Solow model), others focus on specific disaster incidents (Horwich 2000; Becker 2005; Asgary et al. 2005). The econometric models are considered useful in disaster impact analysis as they not only address the issue of uncertainty through providing stochastic estimates but also are statistically rigorous and have forecasting capabilities (Rose 2004). This section provides a few examples of the econometric modelling approaches undertaken to derive the empirical findings of disaster impacts, which basically attempt to estimate the impact of disaster magnitude (in terms of economic damage and/or human suffering) on national economy.

The International Institute of Applied Systems Analysis (IIASA), in partnership with Swiss Re and the World Bank, has developed a macroeconomic model to estimate disaster impact on a nation's economy through incorporating potential future losses of natural disasters into current national development planning. The technique integrates probabilistic natural hazard losses by using sampling data from Swiss Re's loss-frequency distribution into the World Bank's macroeconomic projection model. In order to shock the capital stock and effective labor force with simulated (Monte-Carlo) catastrophic events, the IIASA module contains a Cobb-Douglas production function with both capital and labor as inputs. The probabilistic losses to capital stock (sampled from Swiss Re's loss frequency distribution) thus serve as input to the macroeconomic model, which consequently calculates the macroeconomic impacts. The macroeconomic effects calculated comprise the indirect effects of capital loss as well as the effects of diverting funds to relief and reconstruction activities (Freeman 1999; Freeman et al. 2002).

Albala-Bertrand (1993) provides one of the most comprehensive macroeconomic studies of disaster events through statistical analysis of the macroeconomic impacts of 28 disasters in 26 countries (mostly developing) during 1960-79. Based on the before-and-after analysis of certain key indicators including GDP, capital stock, agriculture output and construction output, the study explains why the key economic variables are not impacted by a disaster. In this model, the recovery patterns of the economies are described in terms of aspects of the political economy of the disaster events thus linking the response strategies to the disasters themselves. The study is in line with the ECLAC approach in the sense that the analysis examines the key economic indicators that may be affected by disasters (Albala-Bertrand 1993; Freeman et al. 2002).

Baritto (2008) hypothesizes that the immediate consequences of disasters can be expressed in terms of a destruction of a country's existing capital stock. In an effort to examine the determinants of total output, the study uses a simplified Cobb-Douglas model. The dependent variable is the GDP of a country while the independent variables are endogenized capital stock and labor. Using standard techniques through logarithmic transformation of the Cobb-Douglas model, the parameters are estimated through the OLS method. As anticipated, the estimates for the coefficients on capital stock and labor do not reflect the full variations in output as part of the output fluctuations is likely to be captured by the error term. Hypothesizing that the unexplained variations in output could be determined by the influence of external shocks, such as those related to natural hazards, the model then incorporates economic losses caused by disasters as an additional explanatory variable in an effort to raise the explanatory power of the model. The study applies an econometric procedure by endogenizing economic losses in the general economic theoretical models explaining total output based on which economic losses are measured in relation to net capital formation[17].

Noy (2009) examines the determinants of natural disasters' short-run ex post impact on a nation's economy using a multi-country framework. Focusing on short-run disaster impacts, the study begins with a simple relationship where the dependent variable is the annual GDP growth rate. The explanatory variables include the measure of disaster magnitude (number of people killed, number of people affected and damages caused), lagged value of GDP growth and a set of control variables commonly used in the short-run growth literature. The model classifies the control variables into two groups, those that are assumed to be (weakly) exogenous and others which are assumed to be predetermined/endogenous and thus correlated with the country specific effects. Since the disaster variable used in the model is expressed as ratio of the previous year's GDP, this variable is classified as predetermined. The Hausman-Taylor three-step estimation methodology is used to correct for the possible correlation between the disturbance term and the variables specified as predetermined/endogenous. Estimates from the first step equations, the country-fixed-effects model, are used to obtain consistent but inefficient estimates for the variance components for the coefficients of the time-varying variables. In the second step, an FGLS (Full Generalized Least Squares) procedure is employed to estimate variances for the time-invariant variables. The third step involves a weighted IV (Instrumental Variable) estimation, using deviations from means of lagged values of the time-varying variables as instruments.

Hochrainer (2009) uses a sample consisting of 225 large natural disaster events during 1960-2005 to examine the macroeconomic consequences of disasters. Two entry points are used for the analysis. First, the empirical study examines counterfactual versus observed GDP and

[17] Specifically, economic losses are measured as a ratio of the sum of economic losses for the entire period to the total net investment for the same period (Baritto 2008).

second, it assesses disaster impacts as a function of hazard, exposure of assets (human, produced, intangible) and vulnerability. In order to forecast GDP into the future after a disaster event, the study uses autoregressive integrated moving average models (ARIMA), as such models are quite commonly used for handling a large number of projections for GDP. Regression models are used to estimate the determinants of GDP growth.

3.2.3 Other Economic Models

Other economic modelling approaches, such as the Input-Output, Social Accounting Matrix and the Computable General Equilibrium models, are being employed to estimate primarily the first-order and higher-order effects of disasters. In recent times, the Input-Output (I-O) models, perhaps the most widely used modelling frameworks in disaster analysis, have become quite popular. As defined in Rose (2004:p.24), I-O model is a static and linear model, which is based on data and information on all purchases and sales between various sectors of an economy, based on the technical relations of production. As the model depends on production interdependencies across sectors, it is quite useful in estimating how damages in some sectors can spread to other sectors (Rose 2004). The model, in general, produces three types of impact assessment: direct, indirect and induced while the addition of all three impacts, expressed as coefficients, gives the total effect – the economic multiplier.

Similarly, the Social Accounting Matrix (SAM) and Sequential Inter-Industry Models (SIM) are increasingly being used to assess the indirect and secondary effects of disasters across different socio-economic agents, activities and factors (Rose 2004; Okuyama and Sahin 2009). In a recent paper, Okuyama and Sahin (2009) examine 184 major disasters in terms of the size of their economic damages. Based on the EM-DAT database and NatCat database, they use Social Accounting Matrix (SAM) methodology to estimate the losses and total impacts (defined as the total of flow impacts, adding the first-order and higher-order effects). The model uses the SAM approach to examine the higher-order effects across different socio-economic agents, activities, and factors. However, the economic models like I-O and SAM have been criticised for not being able to adequately deal with the supply-side constraints in terms of damage to regional capital stocks and transportations systems in the aftermath of a disaster in addition to difficulties in identifying direct and indirect effects. Nonetheless, the empirical findings based on these approaches are encouraging primarily due to their added advantages, for instance, Okuyama and Sahin (2009) acknowledge that although the SAM approach has rigid coefficients and provides upper bound estimates of disaster impacts, this framework, with some disaggregation, can derive the distributional impacts of a disaster so as to evaluate equity considerations.

As an alternative modelling approach, lately, CGE (Computable General Equilibrium) technique is being increasingly used for disaster analysis. In the context of disaster impact studies, CGE model has been defined as “a multi-market simulation model based on the simultaneous optimizing behaviour of individual consumers and firms in response to price signals, subject to economic account balances and resource constraints" (Rose 2004:p.26). CGE models are employed by several disaster researchers, for example, Rose and Guha (2004) implemented a CGE model for a regional economy using the case study of Tennessee focusing on the impact of electric power disruption in a disaster event.

Use of various economic models in disaster analysis in recent years appears growing mainly due to increasing availability of information on disaster damages and increasing progress made in collaboration across various disciplines.

Rose (2004) and others (for example, Clower 2005) believe that the modelling approaches like the I-O, SAM and CGE frameworks, are well-suited to performing distributional analysis as they disaggregate the economy into various sectors providing insight to the characteristics of direct/indirect impacts across various sectors, socio-economic agents and activities. However, Ellson et al. (1984) argue that disaster impacts can only be estimated and subsequently utilized for reliable comparisons and policy analysis if the impacts are based on "with and without" analysis rather than a "before and after" look or a simple time-series extrapolation.

Apart from rigorous data intensive models, a few studies have used eclectic approach in undertaking assessments of economic and financial impacts of natural disasters primarily relying on qualitative methods along with in-depth country level case studies (Benson and Clay 1998; Benson and Clay 2004). These studies observe that the eclectic approach based largely on qualitative methods is quite useful in understanding the pathways through which different types of hazards affect an economy, the different risks posed and the ways in which societies cope with these threats.

4. Issues on Disaster Impact Estimation

The task of identifying and examining disaster impacts on a nation's economy is enormous. The impacts are hard to estimate, more so for indirect (first-order and higher-order) impacts. Economists and social scientists have resorted to various techniques not only to assess disaster impacts but also to understand the pathways through which disaster events interact with the socio-economic dynamics of a nation (Benson and Clay 2004). However, the existing literature indicates that the process involves various constraints related primarily to data and methodologies (Clower 2005; Rose 2004; Adhikari and Yoshitani 2009; Tschoegl 2006; Okuyama and Sahin 2009). Although most of the data issues and methodological issues are interlinked with each other, this section, for convenience, discusses these separately.

4.1 Data Issues

The modelling techniques for estimating disaster impacts, ranging from the ECLAC model to the econometric and other economic models, require availability of extensive data and information on disaster events and their effects. The techniques – however valuable they might be – will hardly provide meaningful results unless supported by adequate, relevant and reliable dataset on disaster events and their effects. Issues related to data and information on disaster events and their effects are many, such as variations in definition of disaster; lack of adequate, reliable and consistent data; differences in classifying the type of disaster; differences in recording the date of occurrence; absence of standardized data collection methodology and ambiguities in classification of disaster impacts (direct, indirect and macroeconomic).

Definition of a disaster does not appear to be consistent across the available databases. For example, EM-DAT defines a disaster as a natural or technological event with damage above a specified threshold level (Rodriguez 2009). Sigma database, which is maintained by Swiss Re, uses a higher level of threshold value.[18] On the other hand, in the DesInventar database, there seems to be no need to define threshold value of damages since those events that tend to generate social losses are included as disasters based on the definition employed (ISDR 2002).

A thorough assessment of disasters' impact requires availability of reliable baseline data and information on the variables of interest, which is hardly the case in many instances. Sometimes the damage caused by a disaster may be unknown due to lack of data on housing, population, infrastructure, etc., leading to difficulties in calculating economic losses, fatalities and number of people affected. At other times, an event may be known but is not reported. In certain instances, figures on disaster damage may be unreliable and/or exaggerated due to vested interest, inefficient reporting systems and political interference while at other times recorded data may differ widely depending on the sources of information thus leading to inconsistencies in damage estimation (Tschoegl 2006; Adhikari and Yoshitani 2009). As an example, the sources for the EM-DAT, which include international aid agencies, insurance companies, respective governments, are all of secondary origin while the sources for the DesInventar include various agencies of national origin. As the primary and secondary sources are not the same in both databases, the task of data verification becomes complicated particularly due to the reason that national governments usually have a tendency to overinflate the associated damage and losses.

Economists working on disaster analysis often report that there exists severe shortage of data and information on the effects of disasters for the reason that the only readily available information through the global disaster databases (those on number of homeless, number of affected, number of dead and injured) is unsatisfactorily defined. This is true for most global databases including EM-DAT, NATCat and Sigma databases. For example, based on the inclusion criteria of EM-DAT, NATCat and Sigma, some fundamental differences exist not only in the definitions of disaster events but also on disaster effects. In the EM-DAT

[18] See Annex 1 for entry criteria for the major international level disaster datasets.

database, following a disaster event, “affected” people includes those who require immediate assistance during a period of emergency and/or those who are displaced or evacuated while the Sigma database does not report data on “affected” people and reports only homeless people. A 2002 paper compares the three datasets based on the disaster events registered during a 15-year period (1985-1999) and highlights that roughly, only one-third of agreement exists across the datasets when the disaster impact magnitude is measured by ‘number of people affected’ since the definition of “affected” varies enormously from disaster to disaster and from reporting source to reporting source (Guha-Sapir and Below 2002). While the same study reports that the concordance level for the variable ‘disaster caused death’ is two-third and the variable damages exhibits the greatest agreement (roughly two-third of the time). More importantly, it should be noted that although comparisons across the three datasets – EM-DAT, NATCat and Sigma – can be misleading as the latter two being reinsurance datasets conceived for their respective clients, the differences across the datasets seem to have reduced significantly over time. Consequently, the three datasets and possibly others should be taken as complementary to each other.

Despite the availability of disaster datasets at various levels, it is ironic that no universal consensus has been established on the data collection process itself. [19] The complexity of data collection process is made even more problematic due to large variations in definitions of indicators, methodologies and data points collected. Various available databases do not publicly disclose the detailed methodological information, which further complicates impact studies due to ambiguity of important variables such as definitions, sources used and inclusion criteria (Tschoegl 2006). The existing discrepancies in information on disaster events not only tend to complicate the task of impact estimation but also complicate the task of classifying disaster types and sub-types and reporting of primary and secondary disasters. It has been seen that different disaster databases at times tend to classify disaster events differently. For instance, a 1985 event in India was recorded as winter storm in EM-DAT but cold/frost in Sigma, while a 1988 heat wave in India as recorded by EM-DAT was identified as a drought/bush-fire in Sigma. This problem is more pronounced particularly while recording primary and secondary disasters, for instance, a flood, which is a consequence of a windstorm, may be recorded as one or the other (Guha-Sapir and Below 2002).

One of the problems that data enumerators usually face relates to difficulties in reporting the date of occurrence of a particular disaster event, for instance, certain databases report incident(s) that fall within a range of time while others provide a specific date of occurrence (Tschoegl 2006). This is more likely to occur in cases of disasters like a flood, which for instance start in June and end one or two months later. While NATCat and Sigma usually

[19] For instance, in all three datasets, EM-DAT, NATCat and Sigma, no difference is made between the two entries, “0” and “missing”.

record a period for the disaster (start/end) (although their criteria for setting the end-date is unknown), EM-DAT records the day it was declared as a humanitarian emergency by one of the primary sources (ProVention 2004).

Furthermore, it has been seen that the available disaster databases at the international, regional and country levels, in most cases, do not record all the disaster events that occurred in the respective countries.[20] For instance, due to the inclusion criteria in the EM-DAT database, several smaller scale disaster events are excluded and more importantly, the dataset excludes various secondary-level disaster incidents as a result of a large-scale disaster event (ISDR 2002).[21] Similarly, NATCat includes only major disaster events and the Sigma database requires higher level of threshold values (for instance, 20 or more deaths) for inclusion, thus suggesting that the global disaster databases are not sufficiently capturing the losses caused by small and medium-scale disasters (Guha-Sapir and Below 2002).

As various organizations have differing identification / classification schemes and define start / end times differently, sometimes searching for the same event is not an easy task. Moreover, it is seen that linkages to the original sources of the information in the databases are not automatically updated, and therefore the most up to date information may not be reflected. Also, as the databases capture different pieces of information, it is often the case that one needs to refer to all the databases individually to get a comprehensive picture.

In an effort to build linkages across various disaster datasets, the recently devised GLIDE (GLobal unique disaster IDEntifier number) concept deserves particular merit based on which each disaster event is assigned a unique ID code. Another noteworthy step was taken in 2007 by CRED and Munich Re who led a collaborative initiative to maintain consistency and usage of terminologies across datasets by establishing a common framework known as 'Disaster Category Classification and Peril terminology for Operational Databases'. The classification, devised through a common understanding between CRED, Munich Re, Swiss Re, Asian Disaster Reduction Center and the UNDP, is believed to represent an important step in the development of a standardized international classification of disaster terminology of perils (Below, R. et al. 2009). However, the actual impacts of these initiatives on disaster impact studies are yet to be seen.

4.2 Methodological Issues in Disaster Impact Estimation

Several methodological issues arise while attempting to examine disasters and their impacts on an economy. The issues can be broadly categorized into definitional issues (conceptual differences between a hazard and a disaster and classification of disaster impacts), accounting issues (valuation of damages/losses of intangible, non-monetary and other

[20] This is more so in earlier years as the data collection process appears to show improvement in recent years.

[21] For example, as a result of, say, a large hurricane, several smaller events like rain, landslides, flooding, can be generated all of which are usually not included in the EM-DAT unless they meet the inclusion criteria.

assets), modeling issues (model specification, prediction), issue of generalization to a wider scale, intertemporal impact issues (differential impacts over a certain time period), spatial issues (differential impacts across geographical regions), and behavioral issues (unpredictable behavior and/or counteractions following a disaster event) (Ellson et al. 1984; UN-ECLAC/WB 2003; Stallings 2006; Rodriguez et al. 2006; Okuyama 2007; Okuyama and Sahin 2009). A closer examination of existing methodologies is, therefore, essential in order to assess their strengths and weaknesses and relevance in understanding the economic and social dimensions of disaster impacts. However, given the complexities involved in the process of understanding the multifaceted nature of disaster impacts, this section can only touch upon a few of the methodological issues considered relevant for the present purpose, which are described below:[22]

4.2.1 Definitional Issues

Assessment of disaster impacts becomes complicated at times when the two terms – hazard and disaster – are sometimes defined interchangeably (Ariyabandu 2001) while at other times differently, depending on the discipline of the research. More importantly, no universally accepted definition of disaster seems to exist. For instance, social scientists in particular, seem to agree that a disaster could mean different things to different people and thus lead to multiple definitions (Quarantelli 2005 cited in Stallings 2006; Perry 2006). Social scientists, usually focus on disasters' disruptive nature and define disaster as an event impacting an entire society or some subdivision and preventing the essential functions of the society (Perry 2006). Similarly, physical scientists and engineers tend to focus more on physical structures including physical and infrastructure damages while economists tend to include disasters' disruption in the flows of economic activities in addition to impact on physical capital stock to arrive at total impact. Disaster researchers on the whole make an argument that the task of defining a disaster should begin with an examination of its fundamentals such as whether disasters are social phenomena or the result of some natural and/or technological process (Perry 2006).

Definitional issues, therefore, arise while classifying basic principles of disaster loss estimation such as classification between direct and indirect effects as no universal distinctions are available yet (Clower 2005). A recent paper by Okuyama and Sahin (2009) observes that no standard definition of economic impact of disasters seems to exist. The same study reports that various documents have used damages, losses and impact of disaster interchangeably, for instance, the EM-DAT uses 'estimated damage' while NATCat uses 'overall losses'. As the task of impact estimation of disasters can be highly multidisciplinary, the assessment process should ideally include experts representing a range of disciplines including structural engineers, scientists, sociologists, psychologists,

[22] For simplicity, the methodological issues are classified into specific headings although in practice, most of those could overlap multiple categories.

economists and representatives of development agencies and humanitarian organizations. Difficulties arise when the experts in charge of disaster cost estimation use multiple terms to describe disaster impacts which are not always consistent (The National Academics 1999; Perry 2006; Stallings et al. 2006; Okuyama and Sahin 2009). Lack of clarity between definitions of disaster related terms, say, direct and indirect effects, will further lead to a number of difficulties including those in classifying the affected population, such as, directly affected or indirectly affected while using the ECLAC methodology, estimating medium and longer-term disaster impacts, estimating higher-order flow impacts on economic activities and/or estimating impact on human capital.

4.2.2. Accounting Issues

Accounting issues arise while estimating damage and losses caused by a disaster event. Valuation of damage and losses involving non-tangible assets and human capital like fatalities requires some standard methods, which at times can be questionable. At other times, the reported damage may reflect a partial picture leading to difficulties in proper valuation.[23] Furthermore, in many instances, reported damage and losses could have been significantly inflated for a variety of reasons including those underlying the political economy. All of this could mean accounting difficulties that often require guesses and approximations on the part of disaster researchers, humanitarian organizations and development partners. The problem gets compounded while estimating higher-order losses, which involve impact on flows of economic activities possibly covering a wide range of sectors over a certain time period (UN-ECLAC/WB 2003; BAPPENAS 2006). Furthermore, at times, it is a challenge to avoid double counting while summing up direct and indirect impacts.

The accounting issues are common to most of the existing impact estimation techniques. For example, for impact estimation using the ECLAC methodology, researchers and development workers face difficulties in quantifying intangible aspects such as human suffering, injuries, fatalities, solidarity, altruism, cultural artefacts, social capital, non-export commodities and subsistence farming, and related cross-cutting aspects like environment and gender (UN-ECLAC\WB 2003; PRC Philippines 2009; BAPPENAS 2009). While using the economic and econometric models, monetary valuation could be particularly challenging in estimating lost opportunities caused by a disaster on the functioning of economic activities, redistributive efficiency and losses in human capital. Furthermore additional difficulties emerge while estimating first-order and higher-order effects as those become apparent at different times after a disaster and thus more difficult to estimate, such as in events like droughts and extended flooding. Some of these issues could further lead to complications in

[23] In many Asian countries, for instance, the governments issue damage estimates but it is not immediately clear if damages to the private properties are also included.

classifying the affected population into meaningful categories such as directly affected and/or indirectly affected.

Despite several attempts to address the issues inherent in classification of disaster damages, certain ambiguities still remain, which are more prevalent in the agricultural sector. In a developing country, these ambiguities are more evident and persistent in assessment of agriculture produce (say, permanent crops versus multi-annual yielding crops, and plantations) and their classification in terms of direct and indirect effects (UN-ECLAC/WB 2003). For instance, a satisfactory assessment of disaster damages in the agriculture sector would mean agreement on matters like estimation of crop losses, and also potential losses in future production losses. Challenges lie in ensuring a right balance between quick efforts versus longer-term efforts, for instance, following the Yogyakarta earthquake, future production losses in affected areas were estimated as much as 10 times the disaster's physical damages in the agriculture sector (BAPPENAS 2006).

Similarly, it is difficult to assess damages and losses resulting in the industry sector due to the ownership structure of the sector since if an industry is privately owned, accurate data and information are rarely collected. In the education sector, while estimating indirect effects, several items need careful consideration like cost estimates of utilizing temporary school premises, cost of recruiting/training new teachers, opportunity costs foregone due to disaster damage, etc., which sometimes require subjective judgements. Similarly, loss estimates in the health sector normally include costs of specific health activities in response to a disaster including costs of recruiting/training health staff, lost wages caused by injuries as a result of the disaster, and the resulting trauma and psychological impacts. The issue can be further complicated by resulting health related problems such as epidemics following the aftermath of a disaster. Additional accounting complications might arise while estimating damage and losses that encompass cross-cutting aspects such as governance, gender, social capital and psychological stresses so that reasonable approximations of disaster damages can be ascertained. Consequently, in order to arrive at reasonable estimates of disasters' direct, first-order and higher-order impacts, and prescribe subsequent mitigation efforts as well as human capital needs, one would require employing most suitable modelling technique and possibly making certain bold assumptions.

4.2.3 Modeling Issues: General considerations

Modeling issues in disaster impact estimation include those related to economic model specification, estimation, forecasting and generalization, and can occur at various levels of impact estimation process. Stallings et al. (2006) believe that in general, the modelling technique chosen to undertake an impact analysis should be able to identify the categories of disaster losses and resulting effects that are being reported and accounted for as against those that should ideally be reported so that suitable measures can be taken to narrow down the discrepancies between the two categories of losses. Disaster impact estimation can be undertaken both following an ex-ante approach and/or ex-post approach. However, in view of several reasons including time limitation following a disaster event, planning of mitigation measures would be more appropriate thereby requiring an ex ante approach based on a modelling methodology that permits forecasting (or simulation) of indirect disaster effects over a period of years (Stallings et al. 2006).

As described in Section 3 of this paper, standard economic modelling approaches like econometric models, Input-Output, SAM, and CGE have been used to estimate and forecast the direct, first-order and higher-order impacts of a disaster. However, each of these approaches is found to exhibit a number of strengths as well as weaknesses. For example, the econometric modelling approaches, in general, are known to suffer from inadequate data, lack of an adequate baseline forecast of variables of interest, inability to incorporate adequately the time and spatial dimensions associated with a disaster event, and inability to incorporate the behavioural changes that might occur after a crisis situation (Ellson et al. 1984; Okuyama 2007; Okuyama and Sahin 2009).

For example, Rose (2004), Clower (2005) and others argue that econometric models, which are based on time-series data that may not include any major disaster events, cannot serve the purpose of conducting disaster impact analysis. Additional difficulties arise when published economic data involve substantial lags constraining the disaster impact analysis. Clower (2005) highlights the challenges that economists face in taking account of a number of economic considerations adequately. For example, most of the econometric models do not easily account for product substitution, immediate changes in trade structure particularly imports, policy changes following a large disaster and the non-linearity of production functions – common consequence of a large disaster. Similarly, economic activity, being a flow concept, can be influenced by a range of factors including other sources of shocks leading to difficulties in isolating the impact of economic losses caused by a certain disaster from other factors (The National Academics 1999; Clower 2005; Baritto 2008).

Regardless of the shortcomings, application of econometric models in disaster impact estimation entails some crucial benefits. Due to their inherent stochastic nature, issues related to uncertainty are automatically incorporated into these models. Also, availability of various diagnostic checks and specific goodness of fit measures enable researchers to conduct testing of individual parameters as well as an entire model and perform various sensitivity analyses. More importantly, the forecasting capabilities of econometric models are useful both for establishing a baseline scenario of a variable in question (say, economic growth) and examining potential impact of future disasters (Rose 2004).

As stated earlier, the Input-Output and SAM modelling approaches (and their extensions) are frequently employed in estimating the first-order and higher-order effects of disasters primarily due to their focus on interdependencies across economic sectors and their ability to accommodate engineering data, useful in multidisciplinary analysis like disaster studies (Rose 2004). However, both the I-O and SAM models suffer from a number of weaknesses and underlying biases due to their linear structure, rigid coefficients, lack of behavioural content, inability to handle supply changes, lack of response to price changes and lack of input and import substitution possibilities (Rose 2004; Clower 2005; Ellson et al. 1984). For example, Ellson et al. (1984) highlight that regional economic models involving the I-O and SAM approaches do not adequately deal with the supply-side constraints in terms of damage to regional capital stocks and transportation systems that are likely to follow after a large disaster. Consequently, due mainly to their disregard towards economies or diseconomies of scale and input/import substitution possibilities, various empirical evidences indicate that these models tend to overstate both the indirect economic losses from disasters and indirect economic gains from reconstruction, thus providing the upper bounds for the impact estimates (Ellson et al. 1984; Guimares et al. 1993; West and Lenze 1994; Bolton and Kimbell 1995; The National Academics 1999; Rose 2004).

Consequently, several refinements of the I-O and SAM methodologies have been suggested primarily to improve their accuracy while applying to disaster impact estimation. For example, attempts to incorporate uncertainty into the I-O models have been undertaken through several ways, which mainly include scenario analyses (contingent forecasts, alteration of major parameters of the model, contingency tests), sensitivity tests and Monte Carlo simulation.[24] However, Rose (2004) highlights that these methods, in most cases, are not based on a sound theoretical framework and thus can be considered ad hoc.

As a more recent approach, the CGE modelling technique, which is increasingly being employed for disaster impact estimation, can be made a lot more flexible compared to the I-O models as it is non-linear in nature, can incorporate dynamic processes for price-quantity adjustment, substitutions across inputs and is able to handle supply constraints. Rose (2004) observes that CGE models, like the I-O and SAM approaches, retain the multisectoral characteristics and emphasis on interdependencies while also incorporating other desirable features like input substitution, import substitution, increasing/decreasing returns to scale, changes in behavioural content and handling of resource constraints. However, CGE models, due to their flexible adjustment feature, tend to underestimate the economic impact of disasters thus more likely to provide lower bounds for the estimates.[25] In addition, the assumption of optimization can be questionable under disaster situations given the

[24] See Rose (2004) for a description of these methods.

[25] Rose (2004) provides excellent examples explaining the inherent biases of the CGE and the other models and their resultant shortcomings. For example, in case of basic I-O models, a 20 percent reduction in lifeline service would lead to at least a 20 percent fall in sectoral output. On the other hand, as estimated by Rose and Guha (2004) using a CGE modelling approach, the same 20 percent reduction in service is expected to lead to only a couple of percentage points drop in sectoral and regional output due to possibilities of substitutions between inputs and imports to overcome the shortages of regionally produced goods.

underlying uncertainties in future (Rose 2004). Above all, the applicability of CGE modelling techniques is largely questionable particularly in a developing country context given their extensive data requirement.

4.2.4 Issue of Generalization

One issue that is often highlighted by disaster researchers relates to the task of generalizing the nature as well as findings of a disaster based on a few case studies to a wider scale. One reason is that the research does not take place until after a particular disaster event has occurred (Ellson et al. 1984). More importantly, as every disaster can exhibit unique characteristics, generalization based on the impact of one disaster to others may be misleading. Stallings (2006) believes that the ability to draw 'valid conclusions' about disasters from post-disaster analysis technique needs to be evaluated in light of three specific issues – the representativeness of the sample surveyed and/or the disaster event itself, "the availability of adequate control groups for inferring causal relationships, and the appropriateness of comparisons across different surveys in the aftermath of separate disasters" (Stallings 2006: p. 67). As for establishing causal relationships, the issue usually involves linking consequences of variables of interest to their magnitude prior to a disaster event. A normal approach would involve constituting a control group, thus requiring identification of a baseline set of variables, usually a description of the unit of analysis (a community, an organization, a nation) prior to the crisis time period. Stallings (2006) has highlighted that a control group should constitute descriptions of conditions, procedures or typical activities before a disaster event so that differences between pre-impact and post-impact patterns can be inferred to have been caused by disaster rather than something else. However, in relation to a disaster event in particular, availability of a baseline scenario could be problematic primarily due to inherent interactive relationship among various agents and activities in an economy.

4.2.5 Intertemporal Impact Issue

Disaster modelling approaches are expected to incorporate the time dimension associated with a particular disaster event. Okuyama (2007) emphasizes that disaster situations normally are characterized by some unique features such as an initial adverse effect (caused by destruction) and the following positive (due to recovery and reconstruction) shocks to an economy over a short period of time. Hence a proper modelling of the time factor in most disaster analysis can be crucial. For instance, while the duration of occurrence of a hazard may be considered short-term in economic sense (say, both the period during a ground shaking before an earthquake and a longer time following a large flood), their impacts can last much longer. But economic models tend rely mostly on annual data due to data constraints for shorter-term. On the other hand, the reconstruction activities can occur at a rapid pace over time and at multiple locations at the same time all of which generate unique features of disaster analysis leading to temporal changes and the resulting temporallyintense interactions of economic activities (Okuyama 2007). Thus, Albala-Bertrand (1993) cautions that all the associated positive and negative effects of disasters may cancel each other out in the long-run provided a static economic model is used thus estimating insignificant total impacts.

Attempts are made to incorporate the dynamic nature of disaster situations by several researchers (Okuyama et al. 2004; Okuyama and Sahin 2009; and others). For example, Okuyama et al. (2004) extend the I-O modelling framework through incorporating the SIM (sequential inter-industry model) modification to accommodate disaster's temporal impact. Similarly, Okuyama and Sahin (2009) use a SIM framework to investigate disasters' higher-order effects. Although a SIM approach is known to handle shorter time framework better than econometric models, it is not considered flexible enough due to its discrete nature (Okuyama 2007). To overcome the issue of discrete time-frame in I-O and SIM approaches, Donaughy et al. (2004) propose a continuous-time formulation of a regional econometric input-output model (REIM) to capture higher-order effects of unexpected disaster events. Dynamic CGE Models are a possibility however, considering the difficulties associated with temporal substitution in a disaster situation and the intensive data requirement of these models, greater initiatives in this specific area are still in progress. More importantly, despite several initiatives taken to account for the dynamic aspects of disaster impact studies, these can be considered ad hoc as in most cases they are not based on sound theoretical foundations as there exists no standard theories justifying their application to disaster events, which can be far away from ordinary events in many respects.

4.2.6 Spatial Dimension Issue

Sometimes, a large disaster can have a wide range of damages and losses across various regions and an appropriate modelling approach is expected to incorporate this spatial dimension adequately so that a thorough understanding of disasters' impact can be achieved. Also, depending on the nature of a particular disaster, sometimes its effects can be unique while at other times the effects can be localized (Albala-Bertrand 2006). On the other hand, in several instances, a large disaster can impact an entire region and/or nation provided the intensities are severe.

Several attempts have been made to properly account for the spatial dimension of disaster impacts, for instance, through the development of an interregional impact analysis since a large disaster's effects can spread well beyond the boundary of that region where the disaster occurred. The models that attempt to examine these interregional impacts primarily use I-O models while incorporating various integrative approaches such as with transportation models for analyzing the spatial distribution of higher-order effects (Okuyama 1999; Sohn et al 2004). For example, through extending the spatially disaggregated economic models, Cole (1998) uses a multi-country SAM to analyze the sensitivity of spatial distribution of damages and higher-order effects. The model is based on country level economic data and GIS-based location data. Similarly, in an effort to address the modelling issues associated with the spatial and intertemporal distribution of disasters' economic impacts, Okuyama et al. (2004) utilize an interregional I-O table within the SIM framework. Consequently in their modification, a static I-O table is extended to a dynamic system with spatial dimension. Along this line, some researchers have proposed uses of various integrative models including spatial CGE models and extended SAM approaches, thus justifying the increasing complexities of estimating higher-order effects and the associated influences of countermeasures (see Okuyama et al. 2004 for more).

Regional econometric modelling approaches are also utilized to examine the spatial dimension of disaster impacts. For instance, Ellson and others (1984) devise a regional econometric model to assess both the short-run and long-run regional economic effects which explicitly models such supply-side constraints as capital investment, housing starts, net-migration and transportation. The model, in addition, incorporates a reasonable degree of spatial disaggregation such that variations of economic effects can be ascertained across the region (Ellson et al. 1984: p. 560).

Disaster researchers, however, feel that traditional econometric models are not always appropriate to account for regional variations in disaster impact studies as these models are specified primarily to estimate the effects of marginal changes in aggregate demand. Ellson et al. (1984) believe that in the context of a disaster event, these models can be inadequate for two reasons. First, the model is expected to assess not only the aggregate economic effects across the region but also the differential effects within the region thus requiring the model be fully simultaneous both within and between areas in the region. Second, there is a greater need to incorporate the supply side factors, relevant in a disaster event, such as infrastructure, housing and capital stock (Ellson et al. 1984, p. 561).

4.2.7 Issues of Behavioral Changes and Counteractions

Sometimes, following a disaster event, a range of non-expected behavioural changes and in-built counteractions on the part of affected population can be seen, particularly during times following a major disaster. These actions can be reflected in the form of, say, altruism, increased remittances, solidarity and abrupt changes in socio-economic resilience of the affected community (Okuyama (2007). Dacy and Kunreuther recognized this unique feature as early as in 1969 and emphasized that the supply and the demand curves may reflect abrupt shifts during the aftermath of a large disaster due to "sympathetic behaviour of mutual aid" during crisis events and the resulting chaotic situation (Dacy and Kunreuther 1969). Various studies highlight the significance of these factors and therefore, an ideal modelling approach is expected to reasonably accommodate their effects.

Some attempts to incorporate the sudden behavioral changes have been made, for example, Okuyama and others (1999) have modeled the effects of decrease in final demand in the rest of Japan after the Kobe earthquake caused by reduced consumption even by those residing outside the affected region (Okuyama et al. 1999, cited in Okuyama 2007, p. 120). Similarly, Rose and Liao (2005) have modelled economic resilience successfully into a CGE modelling framework (Rose and Liao 2005; and others). The production function in their model incorporates inherent resilience (defined as the ability to substitute inputs and/or reallocate resources under normal circumstances) of individual businesses while at the same time takes account of adaptive resilience (the additional ability in crisis situations), which is reflected through the changes in the parameters (Rose and Liao 2005, cited in Okuyama 2007, p.121). However, in a developing country context, attempts to model these behavioural issues could pose severe challenges primarily due to scarcity of reliable data and information. Furthermore, as behavioral issues in general encompass a range of cross-cutting areas including the informal support system, all of which at times might complicate the task of model specification and estimation. More importantly, a sound theoretical framework is essential in order to develop reliable and proper modelling approaches.

4.2.8. Summary of Findings on Data and Methodological Issues

The task of estimating disasters' effects on a nation's development is made complicated in many respects and this section has described a few of those that are considered relevant to economists and social scientists. The issues begin early in the process, for example while conceptualizing and distinguishing between various categories of disaster impacts. The resulting confusions combined with interchangeable uses of terminologies like damage, losses, direct effects and indirect effects, can lead to ambiguous and unreliable estimates. Recent efforts to standardize these concepts, for instance, classification of disasters' indirect effects into first-order and higher-order effects, are noteworthy. However, estimation of these effects requires reliable and consistent set of data and information on disaster events.

Two key data issues are an absence of reliable and consistent database on disaster events and a standardized methodology of data collection. Although, disaster literature shows that the observed discrepancies across various datasets have decreased over time, data issues still complicate the task of impact estimation of disasters. Consequently, there seems to be an urgent need to devise standard methods to collect data and information related to disaster events and their effects. The classification of indirect effects into first-order and higher-order effects is conceptually sound from a modelling perspective especially in the context of a developed country for which relevant models and data may be available. However, this may not be the case for developing countries for which estimation of higher-order effects in particular, is likely to encounter numerous practical difficulties primarily of data collection.

Given the existing data issues, it is not surprising that in most cases the available data on disaster events and their effects usually reflect direct and some indirect effects on capital and inventory provided by humanitarian organizations, government bodies and insurance agencies while most of the indirect and macroeconomic effects are unavailable especially for developing countries (World Bank 2007). Although data on direct losses caused by disasters provide necessary information as well as foundations for modelling purposes, they do not depict the complete effects of disasters (Guha-Sapir and Below 2002).

Economic models, in general, are based on some standard assumptions, which are not always realistic in the context of a disaster event. For instance, most economic modelling frameworks assume gradual and incremental changes over time and uniform impact over space and thus in a disaster situation, these models may not capture the abrupt interruption - over time and space – caused by a disaster event. Besides abruptness, another aspect of disasters is their uniqueness. Disaster events are normally characterized by some unique features such that exactly the same disaster may never occur in future. Furthermore, disasters' impacts may differ depending on relative significance of a wide range factors such as remittances, existing support system (formal and informal), solidarity (and/or lack thereof) and behavioural changes in a disaster event, all of which should be reasonably accounted for while attempting to investigate disasters' full impact.

Consequently, it is not surprising that researchers point out difficulties in accounting for these specific characteristics that a disaster might exhibit using a general purpose economic model (Clower 2005; Okuyama 2007). As reviewed in this paper, several attempts have been made to adequately account for these characteristics associated with disaster events. While extension and refinement of impact estimation procedures and the corresponding modelling frameworks are important, they can never guarantee to capture the full effects of each and every disaster event and therefore it is important for disaster impact analysis to dwell more on a sound theoretical foundation. Naturally, incorporation of the related factors (and perhaps other relevant considerations) into disaster impact analysis, need to be supported by additional multidisciplinary research.

5. Disasters in Southeast Asia: an Introduction

5.1 Disaster Situation and Trend

This section briefly describes the disaster situation and trend in Southeast Asia with particular focus on Indonesia and the Philippines. Historical evidences indicate that Southeast Asia has been particularly prone to natural and technological disasters. The recent incidences of catastrophic events and the resulting consequences particularly in Indonesia and the Philippines appear even more disturbing.

Table 5.1 provides a summary of disaster events, natural and technological, and their direct consequences in five countries of Southeast Asia – Indonesia, the Philippines, Malaysia, Thailand and Singapore. Data indicate that while the first four countries are highly exposed to disaster events in this region, Singapore appears to be relatively immune to natural disasters due mainly to its geophysical location. The nature of disaster proneness in the remaining four countries is evident in the earlier decades and seems to be worsening as shown by an increasing trend of almost all the indicators of disaster magnitude - number of disaster events, total number of people killed, total number of people affected and average annual damage costs (see Table 5.1)[26].

Table 5.1: Natural and Technological Disasters in Southeast Asia, 1970-2008

1970-1979

Country	No. Events	Total no. killed	Total no. affected	Total damage costs (in 1000 US$)	Average Annual Damage Costs (in 1000 US$)
Indonesia	41	4,917	4,773,752	290,750	29,075
Malaysia	3	61	246,050	37,000	3,700
Philippines	108	13,513	15,588,767	1,202,564	120,256
Thailand	7	585	5,031,408	445,000	44,500
Grand Total	159	19,076	25,639,977	1,975,314	197,531

1980-1989

Country	No. Events	Total no. killed	Total no. affected	Total damage costs (in 1000 US$)	Average Annual Damage Costs (in 1000 US$)
Indonesia	100	5,304	2,644,401	432,888	43,289
Malaysia	10	332	107,082	12,363	1,236
Philippines	162	15,089	26,118,772	1,663,626	166,363
Singapore	1	24	0	0	0
Thailand	25	2,002	3,808,912	1,109,646	110,965
Grand Total	298	22,751	32,679,167	3,218,523	321,852

1990-1999

Country	No. Events	Total no. killed	Total no. affected	Total damage costs (in 1000 US$)	Average Annual Damage Costs (in 1000 US$)
Indonesia	142	10,868	7,123,665	10,646,952	1,064,695
Malaysia	33	1,366	80,575	373,000	37,300
Philippines	150	16,298	38,325,008	3,287,323	328,732
Singapore	4	4	1,448	6,137	614
Thailand	68	2,705	22,079,796	2,905,588	290,559
Grand Total	397	31,241	67,610,492	17,219,000	1,721,900

2000-2008

Country	No. Events	Total no. killed	Total no. affected	Total damage costs (in 1000 US$)	Average Annual Damage Costs (in 1000 US$)
Indonesia	228	182,187	8,889,256	10,192,743	1,132,527
Malaysia	35	349	450,398	1,501,000	166,778
Philippines	163	10,331	36,877,460	1,257,474	139,719
Singapore	2	35	2,227	0	0
Thailand	79	9,929	28,021,797	2,104,624	233,847
Grand Total	507	202,831	74,241,138	15,055,841	1,672,871

Source: "EM-DAT: The OFDA/CRED International Disaster Database www.emdat.be -

[26] As indicated earlier, the total damage figure for the 2000-2009 decade would be much higher when, for instance, the estimated damages caused by 2009 West Sumatra Earthquake in Indonesia and typhoons Ketsana and Parma in the Philippines are included.

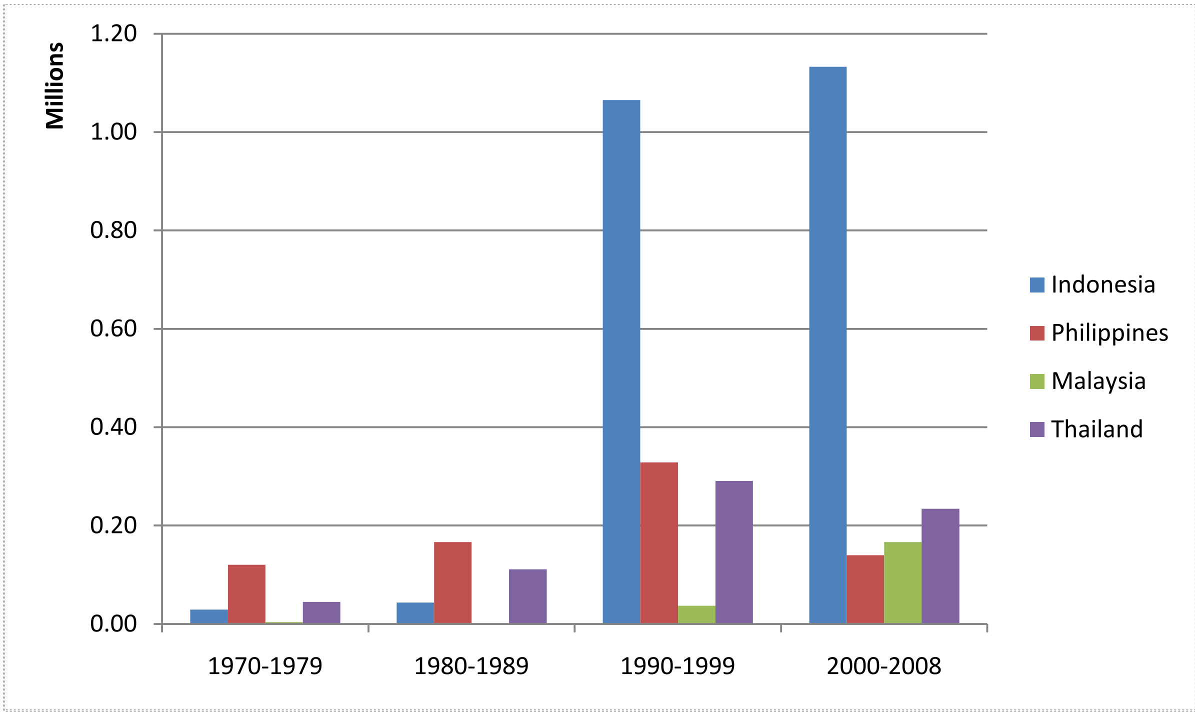

Figure 5.1: Average Annual Damage Costs of Natural and Technological Disasters (in million US$)[27]

Fig 5.1 shows a steady increase in the average annual damage of disaster over the decades except for slight drops in those figures during 2000-2008. Fig. 5.1 depicts the trend in average annual disaster (natural and technological) damage indicating an abrupt increase in the figure during the decade beginning the 90s compared to the 80s. When 2009 disaster damage figures are included, the decade of 2000-2009 would stand out as the decade with the highest losses for both Indonesia and the Philippines.

Within Southeast Asia, Indonesia is a country which is highly vulnerable to natural disasters. As Indonesia lies near the intersection of shifting tectonic plates, it has a very high exposure to seismic activities like earthquakes and volcanic eruptions. As shown in Table 5.1, Indonesia tops the list with respect to the three disaster magnitudes – the total number of people killed, total number affected and total damage costs - during all the four periods covered. This indicates that Indonesia is the most affected countries in Southeast Asia while Singapore is the least affected as a result of the natural and technological disasters. As shown in Fig. 5.2, during the period 1970-2008, natural disasters' adverse impact on Indonesia shows a steady rise both in terms of total damage caused and number of people affected.

[27] Data source: "EM-DAT: The OFDA/CRED International Disaster Database www.emdat.be - Université Catholique de Louvain - Brussels –Belgium"

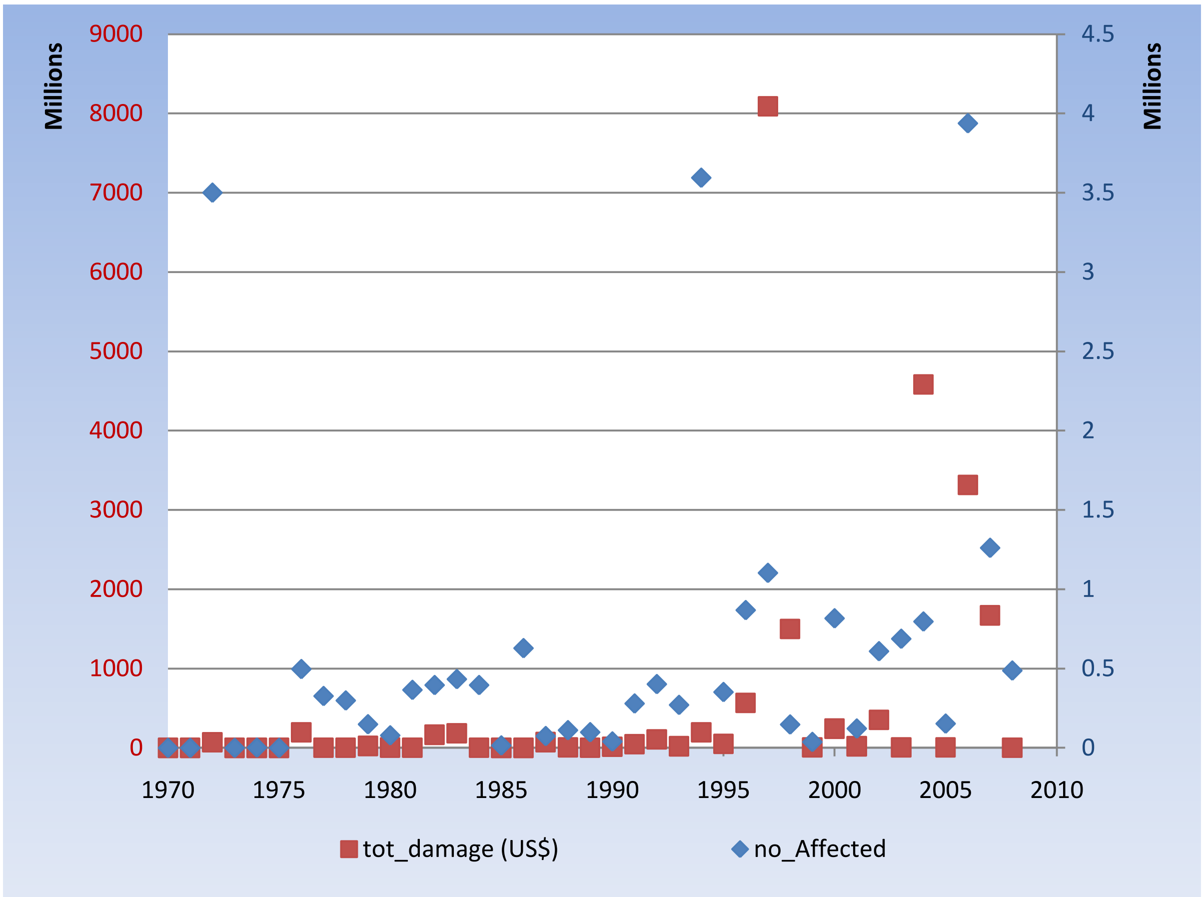

Fig. 5.2 Indonesia: Total Damage and Total Number of People Affected by Natural Disasters (1970-2008)[28]

The Philippines is considered as one of the most hazard prone countries in the world. Due to its geographic circumstances, the Philippines has an unusually high exposure to natural hazards. The most catastrophic of these hazards include tropical cyclones, earthquakes, volcanic eruptions, floods and droughts. These events have had grave social and economic consequences on the country, for instance, costing an average of US$ 140 million per year in direct damages between 2000 and 2008, and killing more than 10,000 people during the nine year period as a result of natural and technological disasters. These figures, however, do not consider the equally devastating indirect and secondary impacts of disasters. More importantly in the Philippines, in addition to the large natural disasters, there are an even larger number of smaller hazard incidents that do not get registered on the global media sources, while those events often adversely affect the poorer strata of the population. As shown in Fig. 5.3, during the period 1970-2008, natural disasters' adverse impact on the Philippines shows a steady rise both in terms of total damage caused and total number of people affected.

[28] Data source: "EM-DAT: The OFDA/CRED International Disaster Database www.emdat.be - Université Catholique de Louvain - Brussels –Belgium"

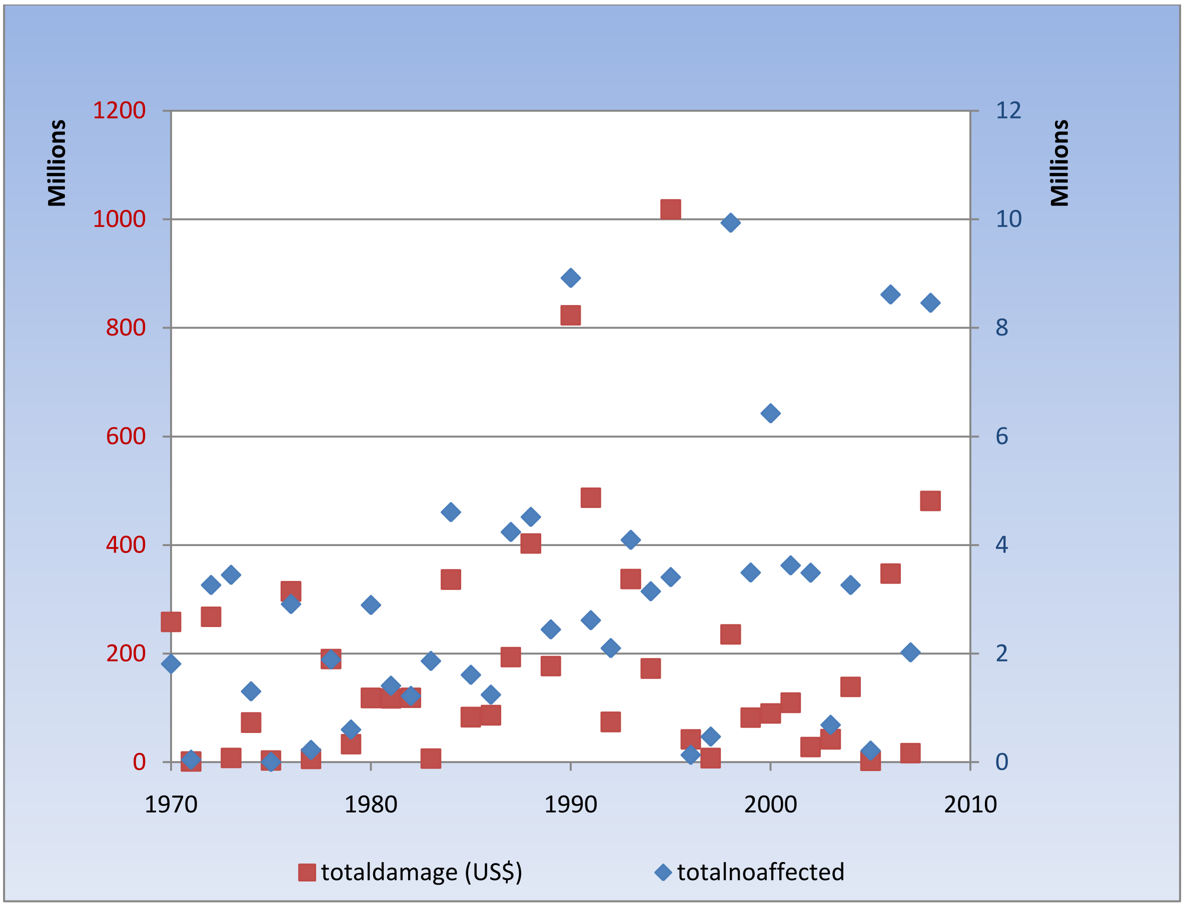

Fig. 5.3. The Philippines: Total Damage and Total No of People Affected by Natural Disasters (1970-2008) [29]

5.2 Case Studies

This section provides a brief summary of three case studies of recent natural disasters in Indonesia and the Philippines. The three case studies cover the Yogyakarta Earthquake 2006 (Indonesia), West Sumatra and Jambi Earthquake 2009 (Indonesia) and Tropical Storm Ketsana and Parma 2009 (The Philippines). Each of the case studies begins with a brief account of the event followed by a summary of major impacts on national economy and major economic sectors. The damage and loss assessment in all three case studies were conducted using the ECLAC methodology.

5.2.1 Yogyakarta Earthquake 2006[30]

On the early morning of 27 May 2006, a large earthquake of magnitude 6.2 on the Richter scale, hit the Provinces of Yogyakarta and Central Java in Indonesia, with its epicenter

[29] Data source: "EM-DAT: The OFDA/CRED International Disaster Database www.emdat.be - Université Catholique de Louvain - Brussels –Belgium"

[30] Source: BAPPENAS (2006), "Preliminary Damage and Loss Assessment Yogyakarta and Central Java Natural Disaster", A Joint report of BAPPENAS, the Provincial and Local Governments of D.I. Yogyakarta, the Provincial and Local Governments of Central Java, and international partners, June 2006 (presented at the 15th Meeting of the Consultative Group on Indonesia, Jakarta, June 14, 2006).

estimated at about 30 kilometers south of Bantul district in Yogyakarta Province. More than 5,100 human lives were lost, more than 10,000 were estimated to have been injured and about 200,000 people displaced.

Table 5.2.1: Yogyakarta Earthquake 2006: Summary of Impact

Category	Damage
Housing	154,000 houses completely destroyed; and about 260,000 partly damaged. Local authorities and the army have set up tents, and temporary shelters are under construction
Employment in productive sectors	Over 650,000 workers were employed in sectors affected by the earthquake
Roads	Several roads and bridges damaged
Airport	Runway suffered cracks; and the terminal building partially collapsed. Air traffic restored on 29 May
Social Sector	Suffered significant damage – health and education hard hit with more than Rp 1.5 trillion in damage and losses; private sector facilities (mostly uninsured) suffered greater losses than the public sector
Rural and urban infrastructure	Most of rural and urban infrastructure remained intact and suffered only minor damage

Source: BAPPENAS (2006)

The earthquake was the third major disaster to hit Indonesia since the 2004 Tsunami. In December 2004, a major earthquake followed by a tsunami devastated large parts of Aceh and the island of Nias in North Sumatra and in March 2005 another major earthquake hit the island of Nias again. Indonesia's high exposure to natural disasters is repeatedly seen as its more than 18,000 islands are located along the Pacific "ring of fire" consisting of active volcanoes and tectonic faults.

The 2006 earthquake caused extensive damage in the housing and productive sectors in the districts of Bantul and Yogyakarta in Yogyakarta Province and Klaten in Central Java Province (see Table 5.2.1).The damage was heavily concentrated on housing and private sector buildings accounting for more than half of the total damage and losses.

As shown in Table 5.2.2, the total damage and losses caused by the 2006 earthquake were estimated as US$ 3.1 billion. The sectoral distribution of the disaster's impact has been atypical, since while the housing sector suffered the severe damage as a result of the earthquake, infrastructure damage and losses were limited. Households and private companies were most strongly impacted by the disaster. Assessments indicate that most of the impact fell on the private sector, in the form of damage to private assets such as houses, other buildings, vehicles and equipment. The damage was concentrated in a few districts; Klaten in Central Java and Bantul in Yogyakarta Province were the most affected.

Table 5.2.2: Yogyakarta Earthquake 2006, Indonesia: Summary of Damage and Losses (Rp in billion)[31]

	Disaster Effects			Ownership	
	Damage	**Losses**	**Total**	**Private**	**Public**
Housing	13915	1382	15297	15296	0
Infrastructure	397	154	551	76	476
Transport and Communication	90	0	90	0	90
Energy	225	150	375	0	375
Water and Sanitation	82	4	86	76	10
Social Sectors	3906	77	3983	2112	1870
Education	1683	56	1739	584	1154
Health and Social Protection	1569	21	1590	1030	560
Culture and Religion	654	0	654	498	156
Productive Sectors	4348	4676	9024	8854	170
Agriculture	66	640	706	700	5
Trade	184	120	304	138	165
Industry	4063	3899	7962	7962	0
Tourism	36	18	54	54	0
Cross-Sectoral	185	110	295	48	247
Governemnt	137	0	137	0	137
Banking and Finance	48	0	48	48	0
Environment	0	110	110	0	110
Total	22,751	6,398	29,149	26,386	2,763
Total (million USD)	**2,446**	**688**	**3,134**	**2,837**	**297**

Source: BAPPENAS (2006)

5.2.2 *West Sumatra Natural Disaster 2009*[32]

On 30 September 2009, a powerful 7.6 magnitude earthquake struck West Sumatra province in Indonesia causing a widespread damage, affecting 13 out of 19 districts and killing over 1,100 people. The geology of the region[33] combined with densely populated settlements in those areas appears to have worsened the damage in terms of lives lost and material losses.

As shown in Table 5.2.3, damage and losses in West Sumatra were estimated at about US$2.3 billion with about 80 percent of all the damage and losses recorded in the infrastructure sectors (including housing) followed by the productive sectors with 11 percent. In line with similar disasters, housing was the worst affected sector, with damage and losses estimated at over Rp 15 trillion. In the productive sectors, trade was the worst

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[31] The 2006 (around June) exchange rate of Indonesian Rp was about 9600 Rp per US dollar.

[32] Source: BAPPENAS (2009), "West Sumatra and Jambi Natural Disasters: Damage, Loss and Preliminary Needs Assessment", A Joint report by the BNPB, BAPPENAS, and the Provincial and District/City Governments of West Sumatra and Jambi and international partners, October 2009.

[33] Seismic activity data over the past 200 years indicate that West Sumatra is particularly prone to earthquakes, due to its location at the convergence zone of four major tectonic plates (BAPPENAS 2009).

affected, reflecting the fact that Kota Padang, a major trading hub in the region, was badly affected by the disaster. Over 88 percent of all damage and losses occurred in the private sector primarily due to large damage and losses in the housing sector, mostly owned privately.

Table 5.2.3 West Sumatra Earthquake 2009, Indonesia: Summary of the earthquake damage and losses (Rp in billion) [34]

	Disaster effects			Ownership	
	Damage	**Losses**	**Total**	**Private**	**Public**
Infrastructure	**16,393.8**	**412.0**	**16,805.8**	**16,326.0**	**479.8**
Housing	15,649.4	297.6	15,947.0	15,947.0	0.0
Transport & communications	327.6	28.8	356.4	61.4	295.0
Roads & Bridges	294.0	9.1	303.1	9.1	294.0
Communications	33.6	19.7	53.3	52.3	1.0
Energy	46.3	6.0	52.3	0.0	52.3
Water & sanitation	370.5	79.6	450.1	317.6	132.5
Water supply	159.9	79.6	239.5	107.0	132.5
Sanitation	210.6	0.0	210.6	210.6	0.0
Social services	**1,484.1**	**205.0**	**1,689.2**	**1,125.9**	**563.2**
Education	593.8	25.0	618.8	510.0	108.8
Health	569.1	175.2	744.3	308.5	435.6
Culture & religion	304.2	3.1	307.2	300.5	6.7
Facilities for the poor	17.1	1.8	18.9	6.9	12.0
Productive sectors	**879.7**	**1,565.7**	**2,445.4**	**2,074.1**	**371.3**
Agriculture	56.1	223.0	279.1	207.3	71.8
Crops	5.1	146.0	151.1	151.1	0.0
Livestock	5.2	2.0	7.2	4.4	2.8
Fisheries	6.8	49.0	55.8	51.8	4.0
Irrigation	39.0	26.0	65.0	0.0	65.0
Trade	673.7	621.5	1,295.2	1,246.9	48.2
Industry	10.9	114.8	125.6	125.6	0.0
Business & finance	68.0	230.2	298.2	64.4	233.8
Bank	63.6	152.2	215.9	61.1	154.8
Non-bank financial	4.4	78.0	82.4	3.4	79.0
Tourism	71.0	376.3	447.3	429.8	17.4
Cross-sectoral	**611.4**	**15.9**	**627.3**	**0.0**	**627.3**
Government	610.8	14.8	625.6	0.0	625.6
Environment	0.6	1.1	1.7	0.0	1.7
Total	**19,369.0**	**2,198.7**	**21,567.7**	**19,526.0**	**2,041.5**
Total (US$)	2,060.5	233.9	2,294.4	2,077.2	217.2

Source: BAPPENAS (2009)

Moreover, many government buildings collapsed resulting in total estimated damage and losses as Rp 0.6 trillion. Infrastructure suffered damage and losses estimated at Rp 16.8

[34] The 2009 (end of year) exchange rate was about 9453 Indonesian Rp per US dollar.

trillion, primarily the result of damage to housing, in line with the extent of damage observed in other similar disasters. About 31 percent of the total housing stock in the affected districts has been either destroyed or damaged in some way, amounting to about 115,000 houses destroyed and over 135,000 houses damaged. Damage to transport infrastructure is relatively limited and concentrated in roads and bridges. The water and sanitation sector suffered severe losses, estimated at almost Rp 0.5 trillion, affecting both the publicly owned utilities as well as private and community water sources.

Damage and losses in the social sectors were relatively limited, at about Rp 1.7 trillion. The earthquake had a significant impact on the productive sectors with damage and losses amounting to an estimated Rp 2.4 trillion. Among these sectors, the trade and industry sector has been the most severely affected. The earthquake has disrupted thousands of small- and medium-sized enterprises (SMEs), mainly located in the urban areas of Kota Padang and Kab. Pariaman. Many traditional and modern markets sustained significant damage. More than 70 percent of the hotel facilities in Kota Padang have been damaged or destroyed. Most tourism-related businesses have suffered from a decline in tourist arrivals following the earthquake. The finance sector has also suffered significantly as more than 2,000 borrowers were reportedly affected following the earthquake.

At the macro level, the disaster is likely to have only a limited impact on the region's economy as West Sumatra accounts for less than 2 percent of national GDP. Similarly, it will not have a significant impact on other macroeconomic fundamentals, such as the balance of payments or the fiscal deficit.

The West Sumatra earthquake was followed by a 7.0 magnitude earthquake the next day in Jambi province with damage and losses estimated at slightly over Rp 100 billion. As in the case of West Sumatra, a large share of the damage is to housing, with little information is yet available on damage to infrastructure and the productive sectors.

As a result of heavy damage and losses caused by the two consecutive earthquakes, it has been increasingly realized that Government efforts should improve the region's preparedness to face similar disasters in the future. Given the geological history of the region – largely prone to seismic activities - it needs to prepare itself better for future disasters. This means undertaking a range of hazard preparedness and mitigation efforts at all government levels to become more resilient to such events in the future, as well as to be able to respond quickly and effectively when such events occur.[35]

[35] The significance of necessary preparedness measures is evident as some seismologists believe that the potential remains for an even larger earthquake to strike West Sumatra, possibly with a magnitude of up to 8.5 Richter Scale. The likelihood of such a major earthquake triggering a tsunami is high, and therefore reconstruction and rehabilitation should be undertaken accounting for this possibility (BAPPENAS 2009).

5.2.3 Tropical Storm Ketsana and Typhoon Pepeng (Parma), September-October 2009[36]

In late September and early October 2009, the Philippines was hit, in quick succession, by two typhoons—*Ondoy* and *Pepeng*—that severely affected over 9.3 million people and resulted in the loss of almost 1,000 lives, with over 700 injured and 84 persons missing. On September 26, 2009, Tropical storm Ondoy (international name Ketsana), the equivalent of a Category I storm, brought an unusually high volume of rain and caused widespread flooding. The severity of the event was indicated by the recorded rainfall of approximately 450 mm at the Manila Observatory, during the 12-hour period. Ondoy caused extensive flooding in the Metro Manila area and the neighboring provinces. Tropical storm Ondoy was quickly followed by typhoon Pepeng (international name Parma), a Category III storm, during October 3-9, 2009. It initially brought powerful winds with gusts of up to 230 km/hr then an extended period of heavy rains, with cumulative rainfall amounts exceeding 1,000 mm in some areas. Based on expert (statistical) estimates, such a rainfall event occurs on average only once in every 50 years.

As a consequence of Tropical storm Ondoy and typhoon Pepeng, the Philippines suffered substantial damage and losses. The storms hit regions of the country that account for over 60 percent of GDP (including the National Capital Region, which accounts for about 38 percent of total GDP). The adverse impacts on the productive sectors were largely due to damaged or lost inventories, raw materials and crops. In addition, business operations were interrupted by power and water shortages, damaged machinery, and absent employees, which contributed to an overall reduction in production capacity. Consequently, the disaster is expected to have a negative impact on GDP growth in the short term. However, after including the projected public and private recovery and reconstruction spending and the associated positive impact on economic activity, the net loss is estimated to be about 2.7 percent of national GDP.

Table 5.2.4: Damage, Losses, and Magnitude of Similar Recent Disasters

Disaster	Country	Year	Total Effects (US$ million)	Magnitude(% GDP)
Earthquake	Pakistan	2005	2,876	0.4
East Asia Tsunami (Aceh)	Indonesia	2005	4,452	1.6
Cyclone Sidr	Bangladesh	2007	1,640	2.8
Cyclone Season	Madagascar	2008	333	4
Cyclone Nargis	Myanmar	2008	4,060	19.7
Storm and Floods	Yemen	2008	1,638	6
TS Ketsana and Typhoon Parma	Philippines	2009	4,383	2.7

Source: PRC, Philippines/ADB/UN/WB (2009)

[36] Source: PRC, Philippines, ADB, United Nations and the World Bank (2009), Philippines Typhoons Ondoy and Pepeng: Post-Disaster Needs Assessment Main report, undertaken by the Public Reconstruction Commission (PRC), Philippines, ADB, UN, World Bank Group and other GFDRR Partners, the Philippines, 2009.

The damage and losses incurred during these disasters are comparable to other major recent disasters across the world (see Table 5.2.4). As noted earlier, the Philippines is frequently affected by disasters and the trend seems to be worsening in 2009 both in terms of number of disaster events and the resulting damage and losses.

Table 5.2.5: Typhoon Ketsana and Parma, Philippines, 2009: Damage and Losses by Sector (in US$ million)

Sector	Damage	Losses	Total
Productive Sectors	557.8	2661.7	3219.5
Agriculture	80.1	769.2	849.3
Industry	209.2	194.1	403.3
Commerce	256.2	1644.4	1900.6
Tourism	12.3	54	66.3
Social Sectors	706.5	212.5	919
Housing	541.6	188.8	730.4
Education	53.5	4.9	58.4
Cultural Heritage	6	0.5	6.5
Health	105.5	18.3	123.8
Infrastructure	181.1	56.2	237.3
Electricity	15.2	18.7	33.9
Water and Sanitation	7.9	16.4	24.3
Flood Control, Drainage and Dam Management	15.3	-	-
Transport	138.7	21.2	159.9
Telecommunication	4.1	0	4.1
Cross-Sectoral	6.3	0.9	7.2
Local Government	6.3	0.9	7.2
Social Protection	-	-	-
Financial Sector	-	-	-
Disaster Risk Reduction and Management	-	-	-
Total (in US$ million)	**1,451.70**	**2,931.30**	**4,383.00**

Source: PRC, Philippines/ADB/UN/WB (2009)

The Post-Disaster Needs Assessment (PDNA) estimated that damage and losses from Ondoy and Pepeng amount to a total of US$4.38 billion (see Table 5.2.5). Damage to physical assets in the affected areas amounted to an estimated US$1.45 billion while the associated losses in production and other flows of the economy were estimated at nearly US$2.93 billion, equivalent to two-thirds of the total disaster effects. While the destruction or damage to assets occurred at the time of the storms, the associated changes in economic flows is expected to longer and some sectors are likely to experience the effects in 2010 and 2011 depending on the speed and efficiency of the post-disaster recovery and reconstruction activities.

As per the details of PDNA, most of the disaster damage and losses are borne by the private sector, which was estimated as US$ 3.9 billion (roughly 90 percent compared to 10 percent in the public sector) (PRC, Philippines/ADB/UN/WB 2009). In contrast to other disasters in which destruction of infrastructure is predominant, nearly 95 percent of total damage and losses were sustained by the productive and social sectors.

Although Ondoy and Pepeng caused substantial damage and losses through directly affecting regions accounting for over half of the Philippines' GDP, the net impact on economic activity is mixed when projected public and private recovery and reconstruction spending were included. 2009 is projected to be affected negatively, while 2010 is affected positively thanks to the large recovery and reconstruction activity expected to take place that year (real GDP growth falling by 0.4 and increasing by 0.4 percentage points of GDP in 2009 and 2010, respectively). Without intervention to recover damage and losses, full-year GDP growth, while likely to remain positive, may be reduced by 1.3 and 0.4 percentage points in 2009 and 2010, respectively. The adverse impacts on the productive sectors were largely due to damaged inventories, raw materials, and crops. At the same time, business operations were interrupted by power and water shortages, damaged machinery, and employee absenteeism.

On the other hand, a social impact assessment based on qualitative research methods such as participant observation, focus group discussions, and in-depth interviews, indicated that tropical storm Ondoy and typhoon Pepeng severely disrupted livelihoods, particularly for farmers and agricultural laborers. Given that about 19.7 million Filipinos or 22.6 percent of the population were estimated to be living below the international poverty benchmark of US$1.25 per day (based on 2006 data), the number of poor people in the Philippines was estimated to have increased by 480,000 in 2009 as a result of reduced economic activity and the resulting income losses. PDNA estimated that about 170 million workdays, equivalent to about 664,000 one-year jobs, were lost, representing about 4 percent of total employment prior to the disasters in the affected regions. Total income lost due to the disasters amounted to Php 50.3 billion[37] particularly affecting informal workers with family-based livelihoods. Microfinance institutions around Luzon reported huge livelihood income losses affecting 164,588 clients across 20 microfinance institutions (MFIs). The commerce sector sustained the biggest losses in employment and incomes in 2009 due to property damage and temporary closedown of some firms and home-based enterprises. The manufacturing industry incurred the second biggest losses in incomes and employment, losing about 150,000 work-years and about Php 13.0 billion in incomes. Informal sector workers were the most vulnerable to shocks from natural disasters, especially small traders and vendors, food-related producers, self-employed agricultural workers, and those relying on

[37] The 2009 (end of year) exchange rate was about 46.7 PHP per US dollar.

subsistence livelihood activities. The post-disaster socio-economic situation further increased their vulnerability in terms of limited opportunities.

5.3 Summary

Section 5 illustrates the high exposure to natural disasters of countries in Southeast Asia particularly Indonesia and the Philippines. The three case studies show the magnitude of the disasters' impacts and the range of sectors affected. These case studies are comprehensive and show the need for a full accounting of disasters' impacts, including those at the sectoral and cross-sectoral levels. All three case studies have used the ECLAC methodology for estimating disaster impacts representing a fairly uniform methodological approach to assess sectoral and cross-sectoral impacts. The adoption of a standardized methodology such as the ECLAC methodology enables inter-disaster and inter-country comparisons. In addition, the methodology can be replicated in future studies.

While the ECLAC methodology is comprehensive, difficulties do exist in obtaining impact estimates particularly of flows of economic activities, due to the associated issues of data, modelling techniques, valuation of intangible assets and others. Despite the shortcomings in its implementation, the ECLAC methodology is to be commended. Therefore to take full advantage of the ECLAC methodology, countries in Southeast Asia should consider strengthening their capacity to conduct post-disaster ECLAC-based impact studies in a routine manner.

One aspect of ECLAC methodology that needs further elaboration / refinement is the manner in which existing intersectoral linkages are assessed. Accounting for intersectoral linkages in an economy is not an easy task but is feasible using techniques such as regional input-output models and SAM modelling techniques. Similarly, econometric techniques can be used to estimate relationship between disaster magnitude(s) and the socio-economic variables of interest. However, the applicability of these models in developing countries are somewhat hampered primarily by data issues. But there is still a need to explore their use to the extent possible to have an in-depth understanding of disasters' impacts in Southeast Asia.

6. Concluding Remarks

This paper has provided an assessment of existing methodologies of estimating socio-economic dimensions of disasters' impacts and the available databases on disaster events. As discussed in the conceptual framework in section 2 of this paper, disasters' impacts (direct and indirect) could interact with a range of socio-economic factors and complicate the task of impact estimation. The available modelling techniques, therefore, face enormous challenges in attempting to adequately model disasters' impacts at a national level. Although recent modelling efforts in disaster analysis, as reviewed in this paper, are noteworthy, disaster impact studies are hampered by data and methodological issues thus making it difficult to get an understanding of the full impact of a disaster on an economy.

The key data Issues in estimating disaster impacts include data inadequacy, data inconsistency, variations in terminologies used in relation to data attributes and the resulting difficulties in identifying disasters and their effects. Some crucial steps are essential in an effort to overcome the data issues. First and foremost, data collection process and methodologies should be standardized. Given the multidisciplinary nature of disaster impact and its estimation, the data collection process should be institutionalized with active participation of all stakeholders, including national (and state, if applicable) government(s), private sector (insurance and reinsurance companies), non-government organizations and international development partners. This will help not only ensure data adequacy and data consistency, but also establish uniformity across the definitions of terminologies and indicators of related disaster variables used in all disciplines.[38]

As shown in this paper, the existing methodologies available for estimating disaster impact face several issues due to the complex nature of impact assessment. Economic and econometric models that are used in disaster impact assessment were not designed specifically for disaster analysis. These models, in general, assume gradual, incremental and uniform changes over time and across space. However, after the occurrence of a disaster event, the usual relationships envisaged in these models tend to get disrupted and the emergency measures taken following the event are not reflected in the models. Consequently, the economic models normally fail to handle the abruptness and largely unpredictable characteristics associated with a disaster event. As an example, following a major disaster event, several factors might come to play such as economic resilience, temporary hiring from outside area, temporary shelter and housing arrangements, increased remittances, aid and altruism, which are usually not considered in the modelling frameworks. Although various modelling approaches are used in disaster analyses, each having its respective strengths and weaknesses, challenges still remain. A proper modelling approach therefore requires careful attention to these effects and perhaps because these factors usually are not taken into account in these economic modelling exercises, the models are reaching diverse conclusions on disasters' impacts. Therefore, as suggested earlier, efforts to incorporate these related aspects need to rely on findings from additional multidisciplinary research.

In the context of Southeast Asian countries, the major impediments to analyzing disaster impacts are issues related to data collection and estimation methodologies, complex nature of disaster impact, inadequate national capacity to undertake impact assessments and high

[38] In this context, the recently established Institute of Catastrophe Risk Management (ICRM) at the Nanyang Technological University, Singapore, deserves particular significance as one of its goals is to evolve as a repository of disaster related data for Asia in particular.

frequency of natural disasters. The ECLAC methodology represents a useful method of impact estimation, however, follow-up analyses need to be undertaken to examine the reliability of impact estimates. For example, estimation of disasters' impact on national GDP should be undertaken routinely as part of the studies on disaster damage. Another important step would be to extend the standard methodology, for example the ECLAC methodology, through incorporating estimation techniques for higher-order effects, which would ensure more accurate estimation of disaster impacts (Okuyama 2009).

More importantly, in the context of Southeast Asian countries, there is an urgent need to compile and standardize data and information related to disasters and their effects. As a start, necessary steps need to be undertaken to create and maintain a comprehensive database on disasters focused on Southeast Asia. Broadly speaking, possibilities of creating a database that would encompass all the countries in Southeast Asia using a common methodology, say, based on an appropriate normalization in terms of population size, inflation rate, incomes/assets, and other key aspects should be explored. As part of this study, preparation of a suitable data collection template should be particularly useful so as to ensure regular and timely collection of data and information related to disaster events and disaster effects in the region.

Along with data collection, case studies of historical disasters should be made and these in turn would serve as the foundation for economic analyses. Another aspect of the problem that could be looked at involves focus on the role undertaken by the governments and other agencies in financing disaster losses. The study, in addition, can incorporate dynamic analysis through examining not only the immediate costs of disasters but also the costs incurred over different time windows[39]. The goal would be to identify risk financing tools and/or risk transfer instruments (or a combination of those) that governments in the Southeast Asian nations have employed in the past. For instance, the research questions that can be examined are: How are governments in Southeast Asia financing their disaster losses? In particular, how have the needs been met, where have shortfalls arisen and how have these governments addressed these shortfalls?

One aspect of disaster impact that is not covered in this paper is the longer-term effects of disasters. Most of the studies on disaster impact focus on short-run timeframe and very few studies examine the long-run impact of disasters on national economy. In practice, estimation of long-run impact is even more difficult because it requires a proper accounting of such factors as total factor productivity, physical capital accumulation, human capital accumulation, natural resources and technology. As an example, disaster's impact on human capital can be much more complex and requires assessment of several interacting factors including damages in terms of injuries and fatalities, damage to educational

[39] Ghesquiere & Mahul (2007) provide an excellent example of the dynamics involved in disaster financing emphasizing that resource allocation and resource gap in funding need to be considered as a dynamic concept.

institutions, and the resulting substitution between physical and human capital following a disaster event. Furthermore, the subsequent longer-run disaster impact will be influenced by national institutional framework, governance structure, preparedness measures undertaken and recovery process following a disaster event. One very useful research area, therefore, could be an exploration of long-run impact of disasters on the economies of Southeast Asian nations – both at the national and regional levels. Specifically, investigation of disasters' impact on human capital and associated complexities would be an interesting area of research. As an extension, the study could examine the influences of national institutions and governance structure on disasters' impacts on human capital constituting another area for further investigation.

This paper has considered only the macro-level impact of disasters on an economy. However, a disaster's impact at a national level may not entirely reflect the true nature of damage unless their differential impacts are also examined. For example, a single disaster can exert varying effects on various population groups and at times more distressing effects on certain groups such as marginalized communities, low-income households, elderly, disabled and women. In developing countries, the lower income strata of the population tend to bear the largest burden of disasters for various reasons including lack of resources, habitation in marginal lands and inadequate access to formal financial institutions.[40] Consequently, studies focused on micro level analysis of disaster impact in Southeast Asian countries are particularly useful in understanding the distributional impact of disasters – across industries, businesses, infrastructure, communities and groups – so that efficient levels of resource allocation, to mitigation and response measures, can be undertaken. Additionally, with the use of a reliable and consistent disaster database on Southeast countries along the lines proposed earlier, necessary efforts can be made to undertake more detailed accounting of disasters' effects, for example, impact studies on livelihood options, human capital and informal economy, all of which are essential in examining an overall development impact of disasters in the region.

REFERENCES

Adhikari, Y. and J. Yoshitani (2009). Global Trends in Water-Related Disasters: an insight for policymakers. International Centre for Water Hazard and Risk Management (ICHARM) and UNESCO.

Albala-Bertrand, J. (1993). The Political Economy of Large Natural Disasters with Special Reference to Developing Countries. Clarendon Press, Oxford.

[40] However, regardless of the economic status of a country, it is usually the case that whenever a disaster strikes, its impacts are disproportionately shared by lower-income groups as seen, for instance, during Hurricane Katrina in the US in 2005.

Albala-Bertrand, J. (2006). Globalization and Localization: An Economic Approach. In Havidan Rodriguez, E. Quarantelli and R. Dynes (Eds), Handbook of Disaster Research, pp. 147-167. Springer, New York.

Ariyabandu, M. (2001). Bringing Together Disaster and Development – Concepts and Practice, Some Experience from South Asia. Paper presented at the 5th European Sociological Association Conference, "Visions and Divisions: Challenges to European Sociology", Helsinki.

Asgary, A. et al. (2006). Lost and Used Post-Disaster Development Opportunities in Bam Earthquake and the Role of Stakeholders. Emergency Management Program, School of Administrative Studies, Atkinson Faculty of Liberal and Professional Studies, York University, Ontario, Canada.

AusAID, USP and SOPAC (2005). Economic Impact of Natural Disasters on Development in the Pacific, Vol 1 and Vol 2. Australian Agency for International Development (AusAID), University of the South Pacific (USP) and the South Pacific Applied Geoscience Commission (SOPAC), Australia.

Balls, A. and Swann, C. (October 8, 2005). Little Sign of Katrina damage as employment figures hold up. Financial Times, 3.

BAPPENAS (2006). Preliminary Damage and Loss Assessment Yogyakarta and Central Java Natural Disaster. A joint report of BAPPENAS, the Provincial and Local Governments of D.I. Yogyakarta, the Provincial and Local Governments of Central Java, and international partners, June 2006.

Beckman, L. (2009). An Annotated Bibliography of Natural Hazards Loss Datasets Derived from the Hazards Loss Dataset Catalog, Natural Hazards Center, Center for Science and Technology Policy Research, University of Colorado, Boulder, Co., April 2009.

BNPB, Bappenas (2009). West Sumatra and Jambi Natural Disasters: Damage, Loss and Preliminary Needs Assessment. A joint report by the BNPB, Bappenas, and the Provincial and District City Governments of West Sumatra and Jambi and international partners, October 2009.

Baritto, F. (2008). Disasters, Vulnerability and Resilience from a Macro-economic Perspective Lessons from the empirical evidence. Background paper for the 2009 ISDR Global Assessment Report on Disaster Risk Reduction (Draft).

Becker, G. (January 4, 2005). And the economics of disaster. Wall Street Journal, A-12.

Below, R., Wirtz, A. and Guha-Sapir, D. (2009). Disaster Category Classification and peril Terminology for Operational Purposes. WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED), University of Louvain School of Medicine, Brussels, Belgium, Working paper 264, October 2009.

Benson, C. and Clay, E. (1998). The Impact of Drought on Sub-Saharan African Economies: A Preliminary Examination. The World Bank Technical Paper 401, Washington DC.

Benson, C. and Clay, E. (2003). Disasters, Vulnerability and the Global Economy. In Kreimer, A., Arnold, M., and Carlin, A., Building Safer Cities: The Future of Disaster Risk. The World Bank, Washington DC.

Benson, C. and Clay, E. (2004). Understanding the Economic and Financial Impacts of Natural Disasters. Disaster Risk Management Series No. 4. The World Bank, Washington DC.

Clower, T. (2005). Economic applications in disaster research, mitigation and planning. Unpublished paper, Center for Economic Development and Research, University of North Texas, Texas.

CRED (2010). "Disaster Data: A Balanced Perspective" in CRED CRUNCH, Issue No. 9, Centre for Research on the Epidemiology of Disasters, Universite catholique de Louvain, Belgium, February 2010.

Cuaresma, J. C., J. Hlouskova, and M. Obersteiner (2008). Natural Disasters as Creative Destruction? Evidence from Developing Countries. Economic Inquiry, 46 (2), pp. 214-226.

Cuaresma, J. C. (2009). Natural Disasters and Human Capital Accumulation. Policy Research Working Paper 4862. Sustainable Development Network and Vice Presidency, Global Facility for Disaster Reduction and Recovery Unit, The World Bank, Washington DC.

Dacy, D. and H. Kunruether (1969). The Economics of natural Disasters. The Free Press, New York, New York.

DfID/ODI (2005). Disasters a Development Concern. ODI Briefing Paper, Department for International Development and Overseas Development Institute, London.

Dlugolecki, A. (2007). The Cost of Extreme Events in 2030: A Report for United Nations Framework Convention on Climate Change, (website source: *http: //unfccc.int /files/ cooperation_and_support/financial_mechanism/application/pdf/dlugolecki.pdf).*

ECLAC (1999). Assessment of the Damage Caused by Hurricane Mitch 1998 Implications for economic and social development and for the environment. UNECLAC, UN.

Ellson, R., Miliman, J. and Roberts, B. (1984). Mesuring the Regional Economic Effects of Earthquakes and Earthquake Predictions, in Journal of Regional Science, Vol. 24, No. 4, 1984, pp. 559-579.

Freeman P. (1999). Estimating Chronic Risk from Natural Disasters in Developing Countries: A Case Study on Honduras. Paper for the Annual Bank Conference on Development Economics-Europe, Development Thinking at the Millennium, June 26-28.

Freeman, P., Martin, L., Mechler, R., Warner, K. and Hausman, P. (2002). Catastrophes and Development Integrating Natural Catastrophes into Development Planning. Disaster Risk Management Working Paper Series No. 4, the World Bank, Washington DC.

Fomby, T., Ikeda, Y., and N. Loayza (2009). The Growth Aftermath of Natural Disasters. Policy Research Working Paper 5002. The World Bank, Washington DC.

Ghesquiere, F. and O. Mahul (2007). Sovereign Natural Disaster Insurance for Developing Countries: A Paradigm Shift in Catastrophe Risk Financing, Policy Research Working Paper 4345, The World Bank, Washington DC.

GTZ (2002). Disaster Risk Management Working Concept, Eschborn.

Guha-Sapir and Below (2002). The Quality and Accuracy of Disaster Data A Comparative Analysis of Three Global Datasets. WHO Centre for Research on the Epidemiology of Disasters, University of Louvain School of Medicine, Brussels, Belgium for the Pro Vention Consortium, The Disaster Management Facility, The World Bank.

Handmer, J. and Dovers, S. (2007). Handbook of Disaster and Emergency Policies and Institutions, Sterling, London.

Horwich, G. (2000). Economic Lessons of the Kobe Earthquake, in Economic Development and Cultural Change, Vol. 48, No. 3, pp. 521-542.

IPCC (2007). Up in Smoke? Asia and the Pacific: The threat from climate change to human development and the environment. The fifth report from the Working Group on Climate Change and Development, Intergovernmental Panel on Climate Change.

ISDR (2001). Updated and Expanded Terminology on Disaster Reduction. International Strategy for Disaster Reduction, Geneva.

ISDR (2002). Comparative Analysis of Disaster Databases. Final Report, International Strategy for Disaster Reduction, UN.

Jaramillo, H. C. R. 2007. Natural Disasters and Growth: Evidence using a wide panel of countries. Documento CEDE 2007 – 14.

Kahn, M. (2004). The Death Toll from Natural Disasters: The Role of Income, Geography and Institutions. Review of Economics and Statistics, 87(2), pp. 271-284.

Loayza, N., E. Olaberria, J. Rigolini, and L. Christiaensen (2009). Natural Disasters and Growth Going beyond the Averages. Policy Research Working Paper 4980. The World Bank, Washington DC.

Mileti, D. S. (1999). Disasters by Design: A reassessment of natural hazards in the United States. Joseph Henry Press, Washington DC.

NAP (1999). The Impact of Natural Disasters: A framework for Loss Estimation, The National Academics 1999.

Noy, I. and A. Nualsri (2007). What do Exogenous Shocks Tell Us about Growth Theories? Working Paper, University of Hawaii, Manoa.

Noy, I. (2009). The Macroeconomic Consequences of Disasters. Journal of Development Economic, 88, pp. 221-231.

Okuyama, Y., Hewings, G.J.D., and Sonis, M. (1999). Economic Impacts of an Unscheduled Disruptive Event: a Miyazawa Multiplier Analysis. In G.J.D. Hewings, M. Sonis, M. Madden and Y. Kimura (Eds), Understanding and Interpreting Economic Structure, pp. 113-144 (Berlin: Springer).

Okuyama, Y. (2003). Economics of natural disasters: A critical review. December 2003.

Okuyama, Y. and S.E. Chang (Eds), (2004). Modeling Spatial and Economic Impacts of Disasters. Springer, New York.

Okuyama, Y., Hewings, G., and Sonis, M. (2004). Measuring Economic Impacts of Disasters: Interregional Input-Output Analysis Using Sequential Interindustry Model. In Y. Okuyama and S.E. Chang (Eds), Modeling Spatial and Economic Impacts of Disasters, pp. 77-102. Springer, New York.

Okuyama, Y. (2007). Economic Modeling for Disaster Impact Analysis: Past, Present and Future, in Economic Systems Research, 19(2), pp. 115-124.

Okuyama, Y. and S. Sahin (2009). Impact Estimation of Disasters A Global Aggregate for 1960 to 2007. Policy Research Working Paper 4963. Sustainable Development Network and Vice Presidency, Global Facility for Disaster Reduction and Recovery Unit, The World Bank and International University of Japan.

Okuyama, Y. (2009). Impact Estimation Methodology: Case Studies. Unpublished paper, prepared for the Global Facility for Disaster Reduction and Recovery (GFDRR) and the World Bank.

Pelling, M., Ozerdem, A. and Barakat, S. (2002). The macro-economic impact of disasters. In Progress in Development Studies, pp. 283-305.

Perry, R. W. (2006). What Is a Disaster?, in Havidan Rodriguez, E. Quarantelli and R. Dynes (Eds), Handbook of Disaster Research, pp. 1-15. Springer, New York.

PRC, Philippines\ADB\UN\WB (2009). Philippines Typhoons Ondoy and Pepeng: Post-Disaster Needs Assessment Main report. Undertaken by the Public Reconstruction Commission, Philippines, ADB, UN, World Bank Group and other GFDRR Partners, Philippines, 2009.

Popp (2006). The Effects of Natural Disasters on Long Run Growth (retrieved from website).

Quarantelli, E.L. (2005). The Earliest Interest in Disasters and the Earliest Social Science of Disasters: A Sociology of Knowledge Approach (Draft).

Raddatz, C. (2007). Are external shocks responsible for the instability of output in low-income countries?, Journal of Development Economics, 84, pp. 155-187.

Raschky, P. (2008). Institutions and the Losses from Natural Disasters. Natural Hazards and Earth System Sciences, 8, pp. 627-634.

Rasmussen T. (2004). Macroeconomic Implications of Natural Disasters in the Caribbean. IMF working paper WP/04/224. IMF, New York.

Rodriguez, H., Quarantelli, E. and Dynes, R. (2006). Handbook of Disaster Research. Springer, New York, USA.

Rodriguez, J., F. Vos, R. Below and D. Guha-Sapir (2009). Annual Disaster Statistical Review 2008 The numbers and trends. Centre for Research on the Epidemiology of Disasters (CRED), World Health Organization and Universite Catholiques de Louvain, Belgium.

Rose, A. (2004). Economic Principles, Issues and Research Priorities in Hazard Loss Estimation. In Y. Okuyama and S.E. Chang (Eds), Modeling Spatial and Economic Impacts of Disasters, pp. 13-36. Springer, New York.

Rose, A. and Guha, G. (2004). Computable General Equilibrium Modeling of Electric Utility Lifeline Losses from Earthquakes. In Y. Okuyama and S.E. Chang (Eds), Modeling Spatial and Economic Impacts of Disasters, pp. 119-142. Springer, New York.

Rose, A. and Liao, S.Y. (2005). Modeling Regional Economic Resilience to Disasters: a Computable General Equilibrium Analysis of Water Service Disruptions, Journal of Regional Science, 45, pp. 75-112.

Sohn, J., Hewings, G., Kim, T., Lee, J. and Jang, S. (2004). Analysis of Economic Impacts of an Earthquake on Transportation Network. In Y. Okuyama and S.E. Chang (Eds), Modeling Spatial and Economic Impacts of Disasters, pp. 233-256. Springer, New York.

Stallings, R. A. (2006). Methodological Issues. In Havidan Rodriguez, E. Quarantelli and R. Dynes (Eds), Handbook of Disaster Research, pp. 55-82. Springer, New York.

Toya, H. and Skidmore, M. (2002). Do Natural Disasters Promote Long-Run Growth? Economic Inquiry, 40(4), pp. 664 – 687.

Toya, H. and Skidmore, M. (2005). Economic Development and the Impacts of Natural Disasters. Working Paper 05-04, Department of Economics, University of Wisconsin – Whitewater.

Toy, H. and Skidmore, M. (2007). Economic Development and the Impacts of Natural Disasters. Economics Letters, 94, pp. 20-25.

Tschoegl, L. et al. (2006). An Analytical Review of Selected Data Sets on Natural Disasters and Impacts. Paper presented at UNDP/CRED Workshop on Improving Compilation of Reliable Data on Disaster Occurrence and Impact, April 2-4, 2006, Bangkok, Thailand.

UNDP (2004). A Global Report Reducing Disaster Risk: A Challenge for Development. Bureau for Crisis Prevention and Recovery, UNDP, New York.

UN-ECLAC/WB (2003). Handbook for Estimating the Socio-economic and Environmental Effects of Disasters, UN Economic Commission for Latin America and the Caribbean and the World Bank.

UN-ESCAP (2008). Economic and Social Survey of Asia and the Pacific 2008 Sustaining Growth and Sharing Prosperity. United Nations Economic and Social Commission for Asia and the Pacific, United Nations, New York.

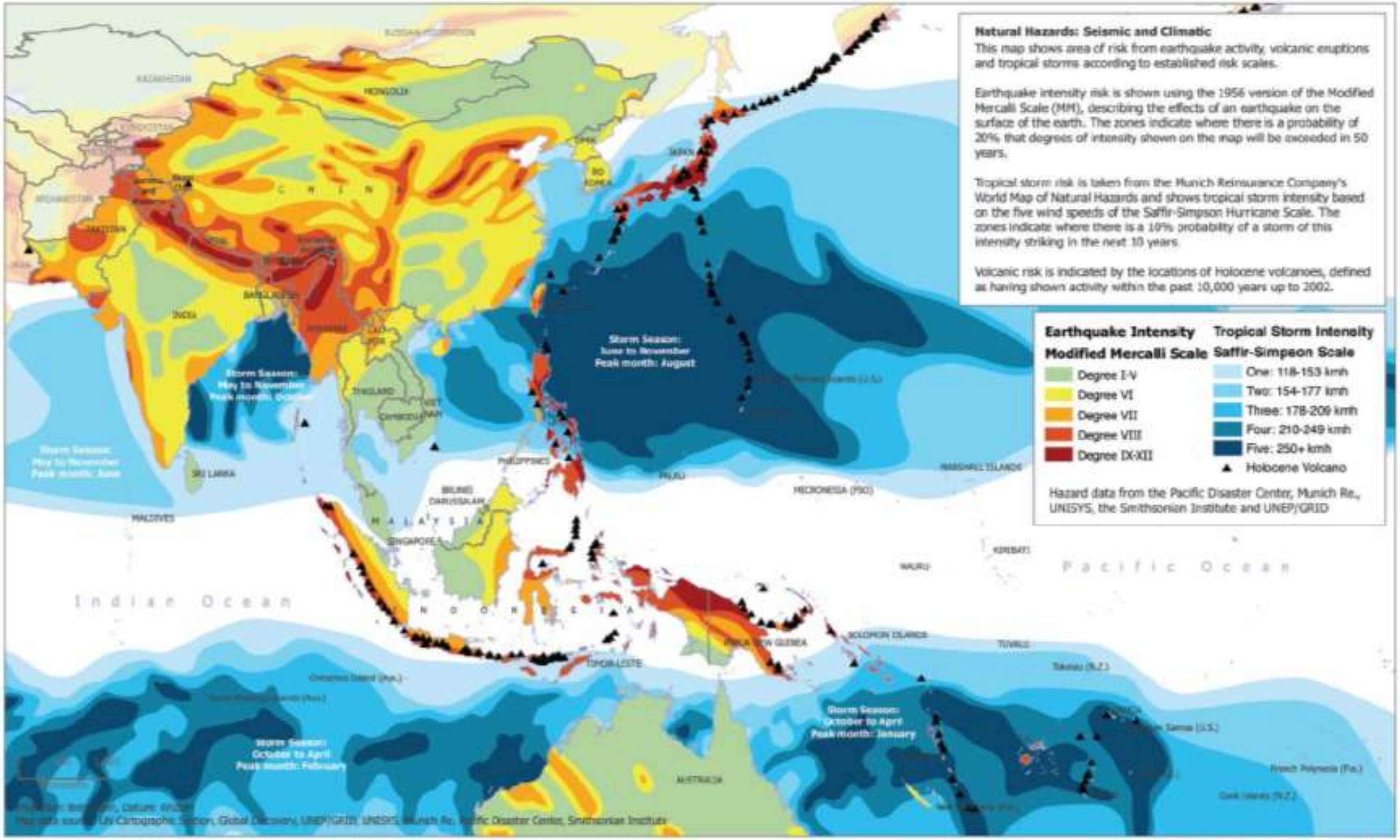
World Bank (2007). Development Actions and the Rising Incidence of Disasters. Evaluation Brief 4, Independent Evaluation Group (IEG), World Bank, Washington DC.

Annex 1: Overview of Major International Disaster Databases

	EM-DAT (CRED)	NatCatSERVICE (Munich Re)	Sigma (Swiss Re)	Disaster Database Project (Univ of Richmond)
Period Covered	1900 - present	1979 - present	1970 - present	
No of Entries	17,000	26,000		over 1800
Type of Disasters	natural (geophysical, meterological, hydrological, climatological and biological) and technological disasters	natural disasters (geophysical, meterological, hydrological, climatological and biological)	Natural and man-made disasters (excluding drought)	natural disasters, conflict-based disasters and human system failures
Entry Criteria	10 or greater than 10 deaths and/or 100 or greater than 100 affected, and/or Declaration of a state of emergency call for international assistance	Entry if any property damage and /or any person sincerely affected (injjured, dead); Before 1970 only major events included	20 or more deaths and/or >50 injured and/or >2000 homeless and/or Insured losses >$16.6 mil (shipping), or $33.1 mil (aviation), or $41.1 mil (other losses) or $82.2 mil (total losses)	represents a threat to life, property or environment; or requires emergency procedures to limit and resolve impact; or causes declaration of emergency; or presence of a significant degree of community or organizational impact
Main Sources	UN agencies, official governmental sources, IFRC, research centres, Lloyd's, Reinsurance sources, press, private	Munich Re branch offices; Insurance Associations; Insurance press; Scientific sources; Weather services; Governmental and non-governmental organizations	Daily newspapers, Lloyd's list, Primary insurance and reinsurance periodicals, internal reports, online databases	Newspapers, scholarly books, government reports
Priority Source	Priority is given to the UN agencies	For monetary losses priority is given to Munich Re branch offices and Insurance Associations	Not specified	Not specified
Access	Public	Partially accessible	Partially accessible	Partially accessible
Users / public	Research centres, governmental institutions, UN agencies, media, private, humanitarian organizations	Munich Re Underwriter, clients, governments, NGOs, scientific bodies, Universities, media, etc.	Annual sigma publication available to those involved in natural hazards issues, insurance companies, brokers, global companies, banks, media, scientific institutions	
Web address	www.emdat.be	www.munichre.com/geo	www.swissre.com	http://learning.richmond.edu/disaster/index.cfm

Sources: Guha-Sapir and Below 2002; Rodriguez et al. 2009; Below et al. 2009; Beckman, L. 2009.

Annex 2: Seismic and Climatic Hazards in South, Southeast and East Asia



The names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations

Map Ref: OCHA_ROAP_Composite_Hazards_v1_060808