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A Review of the Nature and Impact of Environmental Disasters in the Philippines

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Lack of systematic comparison of the frequency and impact of various types of environmental hazards is a deterrent to sound hazard management and to theory development on Philippine disasters. Government records over the past 25-35 years on ten classes of environmental hazards – tropical cyclones, floods, landslides, volcanoes, earthquakes, tsunamis, droughts, pest infestations, health diseases, and "technological accidents" – were thus compiled and synthesized. Impact was measured in terms of fatalities, houses completely destroyed, and monetary costs of damages. Technological accidents, floods, tropical cyclones are the three most frequent disasters while tsunamis, volcanic eruptions, and droughts occur the least. In terms of Peso value, droughts, earthquakes, and volcanic eruptions are the most severe while pest outbreaks, landslides and health epidemics inflict the least monetary damages. Over the last 30 years or so, the costs of destructive floods, typhoons, and droughts appear to be generally increasing over time, highlighting Filipinos' increased vulnerability to these environmental threats. Using the documented frequency and severity of environmental calamities in the country since 1970 and concepts suggested by Wildavsky (1988), a new framework for national government response to hazard mitigation is proposed. Three generic strategies are identified: resiliency *(droughts, earthquakes, volcanoes, tsunamis),* anticipation *(typhoons, floods, pests) and* prevention *(landslides and health epidemics).*

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Introduction

Two recent studies of the Philippines' national capacity for natural disaster risk management highlight its reactive tendency, focusing on short-term preparedness (*i.e.* forecasting and evacuation) and post-disaster relief (UNDAC, 2005; WB/NDCC, 2004). But in order to reform the system to a more effective approach oriented towards long-term hazard mitigation, the WB/NDCC admit that there is a need for "a more detailed review of …disaster risk management to identify gaps and priorities" (2004, p. 8). A particular deficiency in this rationalist approach to disaster studies and management is the rather scanty publication on fatalities, properties destroyed, and monetary damages of various types of hazards. Although a few case studies document the impacts for well known events – such as the M 7.8 July 1990 Luzon earthquake, 1991-1992 Pinatubo eruptions, and the 1997-1998 El Nino (Rantucci, 1994; Mercado et al., 1996; Monsalud et al., 2003) –systematic comparison of the impacts of *various* types of environmental disasters in the country has not been available. As a consequence, the broader implications of environmental disasters to Philippine life are assessed with great limitations. For example, attempts to relate and quantify the impact of disasters on Philippine poverty and development situation either focus on a particular hazard such as typhoons (WB/NDCC, 2004) or lack systematic statistics for several environmental threats (CDRC, 1992). Similarly, designing flood control projects in Metro Manila is hampered by the lack of data to assess flooding economics (Tabios et al., 2000). Theory development and risk management practices on Philippine disasters will thus benefit if disaster statistics are propagated to concerned scholars and practitioners rather than stored in government record vaults.

Although systematic scientific monitoring of certain natural phenomena has a long tradition in the country (dating back to the Spanish-era for earthquakes and typhoons), the assessment of disaster impacts (number of fatalities, houses destroyed, financial damages, etc.) began only in the late 1970s with the creation of the National Disaster Coordinating Council in June 1978 through Presidential Decree 1566 (UNDAC, 2005). In this paper, I review the nature of and present statistics on Philippine environmental disasters with a particular focus on post-1970 events where data are more reliable though far from complete. The statistical compilation should serve as a useful baseline for informing risk mitigation practices and for conceptual models of disaster analyses. More specifically, the paper attempts to answer two fundamental questions: 1) what are the most prevalent environmental disasters in the country? and 2) are there discernible temporal trends in the frequency and impact of various environmental disasters? In seeking the answers, I relied on secondary data principally from the Office of Civil Defense/National Disaster Coordinating Council (OCD/NDCC) supplemented by information culled from other disaster-related agencies notably the Philippine Atmospheric Geophysical and Astronomical Administration (PAGASA), the Philippine Institute of Volcanology and Seismology (PHIVOLS), the Department of Social Welfare and Development (DSWD), the Department of Agriculture, and the Department of Health (DOH).

The lack of agreement on the scale of destruction produced by an event to qualify as a disaster provides substantial arbitrariness in categorizing such events. The Centre for Research on the Epidemiology of Disaster (CRED) at the Louvain Catholic University (Brussels) requires any one of the following for an event to be entered into its database: ≥ 10 people reported killed, 100 people reported affected, a call for international assistance, and a declaration of a state of emergency (EM-DAT, 2005). The OCD/NDCC records events in its database if lower-level disaster coordinating councils report "significant" effects from their perspective in terms of casualties, families affected, and properties lost; this is true whether or not such events are eventually declared as "state of calamities" that trigger official government response (UNDAC, 2005; World Bank/NDCC, 2004; M. Tadeo, pers. comm., 2006). The DSWD's Disaster Response Operation Monitoring and Information Center (DROMIC), operating since 1992, records any "disturbances" reported by DSWD field staff and local government units (LGUs) social welfare officers, regardless of whether the DSWD provided some assistance. (R.Martija, pers. comm., 2006). Due to this lack of agreement, I use four measures whenever possible to describe disaster effects at the individual (number of casualties), household (number of families affected, number of houses completely destroyed) and regional levels (nominal Peso value of damages). For consistency, the monetary value of damages is arbitrarily used here as the measure of the severity or destructiveness of events. The extent of disasters are also described in terms of the country's administrative regions (Figure 1) or more precise location whenever possible[1].

The paper is structured into three short sections. The first section describing the nature and impact of specific environmental hazards is followed by a brief integrative discussion on Philippine environmental disaster trends. The study's implications for disaster management and scholarship are highlighted in the concluding section.

Environmental disasters: The nature of hazards and their impact

The long-standing classification of disasters into *natural* and *man-made* has recently and rightfully come under disfavor due to the increasing and complex overlap between environmental and man-made causes. Because it is essentially people – through their lives, activities, and properties (their vulnerability) – who transform danger (or hazards) into calamities, it makes sense to treat all disastrous events as a continuum between purely natural and man-made. For this reason, the term *environmental disaster* is preferred. Following Smith (1996), environmental disaster is defined as:

> *extreme geophysical events, biological processes and major technological accidents, characterized by concentrated releases of energy or materials which pose a largely unexpected threat to human life and can cause significant damage to goods and the environment (p.16).*

Such definition focuses attention on relatively rapid-onset conditions (except droughts) and excludes such "elusive hazards" as "deforestation, desertification, depletion of the …ozone layer, global warming, and rising sea levels" which though not unimportant "are generally less concentrated in time and space and create fewer deaths" (Smith, 1996). I adopt this perspective in this paper for practical reasons because though the country is vulnerable to most of these so-called elusive hazards (Manila Observatory, 2005), systematic documentation of their *effects* remains methodologically problematic. Thus, the environmental hazards considered in this paper include those arising from the country's geographic setting (*i.e.*, tropical cyclones, floods, volcanoes, earthquakes, tsunamis, droughts) and those that have stronger human components (*i.e.*, pest infestations, health epidemics and "industrial" accidents).

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[1] The use of regions to delineate disaster extent follows that of OCD/NDCC and DSWD-DROMIC records. Changes in Philippine administrative region nomenclature make direct comparison of disaster extent through time using regions somewhat complicated. Beginning with eleven (11) administrative regions in 1972, NCR was created in 1975 from Region IV, the Autonomous Region of Muslim Mindanao (ARMM) region carved out in 1989 from Regions IX and Region XII, and the Cordillera Administrative Region (CAR) in 1989 from Region I. Central Mindanao (Region XII) now consists of only Lanao del Norte, Sultan Kudarat, and (North) Cotabato. In 1995, CARAGA region was created from Region's X eastern provinces. See "Regions of the Philippines" in http://en.wikipedia.org/wiki/Regions_of_the_Philippines. Retrieved, January, 2006.

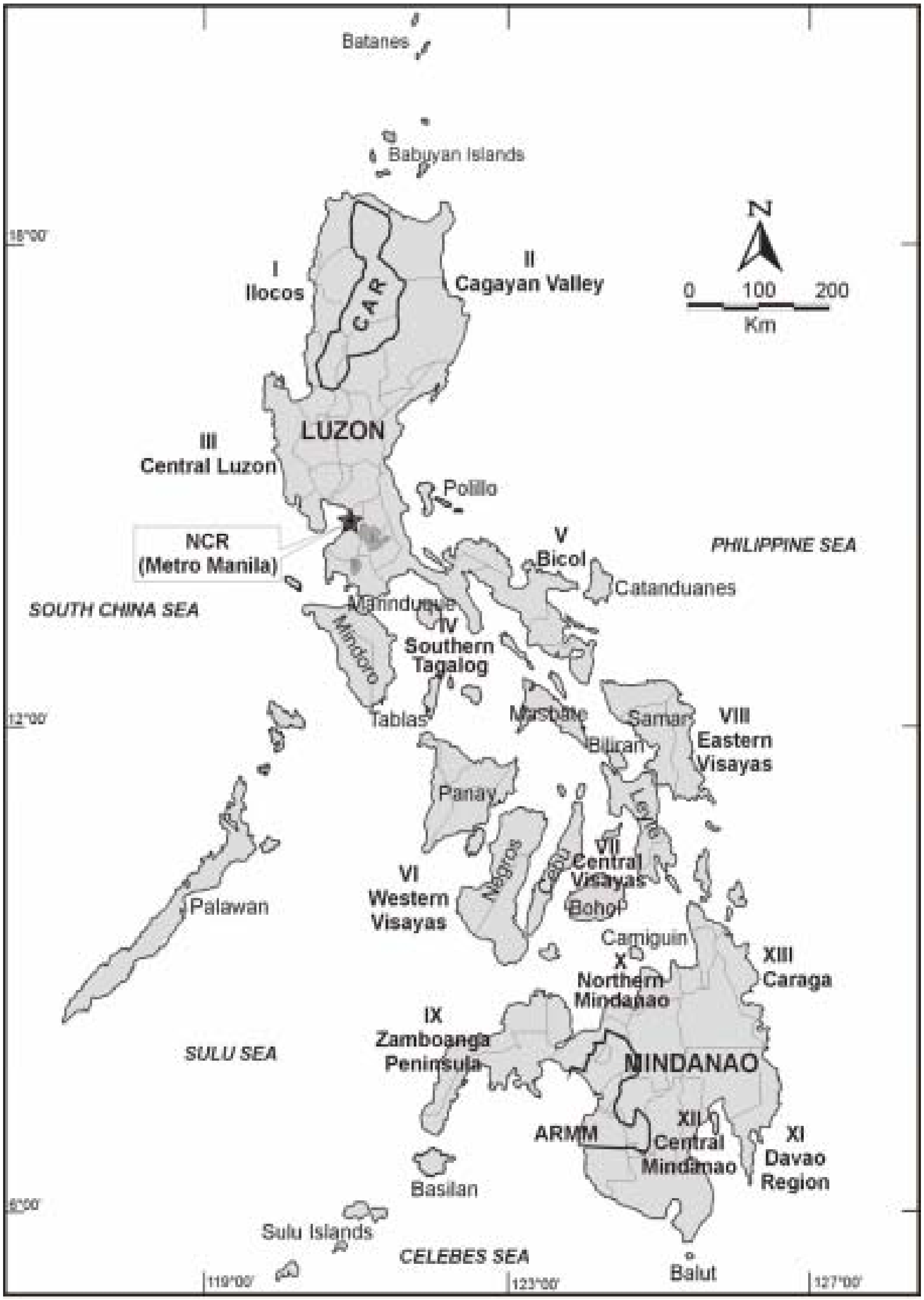

Fig. 1. Major Islands and Administrative Regions of the Philippines

Tropical cyclones

Tropical cyclones are large circulating systems of clouds, winds, and thunderstorms formed over oceans driven by the heat released by water vapor condensing at high altitudes. That warm ocean water and moist air are crucial ingredients of cyclone formation are central to why nearly all cyclones form within 10° to 15° of the equator (Kovach, 1995). Of the seven major ocean basins of cyclone formation, the western North Pacific Ocean that surrounds the Philippines, Taiwan, and Japan is widely considered the most active (Kovach, 1995; Smith, 1996). Depending on their intensity and associated wind speed, tropical cyclones are usually classified as: 1) *tropical depression* (maximum wind speed of 63 kph), 2) *tropical storm* (64-118 kph), and 3) *typhoon* (or *hurricane* in the Atlantic and Northeast Pacific basins, >118 kph) (PAGASA, 2001a; 2005a).[2]

Between 1948 and 2005, 1,135 tropical cyclones were recorded within the Philippine Area of Responsibility (PAR) yielding an average of twenty (20) tropical cyclones per year (PAGASA, 2005b). Of this number, more than half (586) were typhoons, 319 were tropical storms and 230 were tropical depressions. Tropical cyclone generation in the country is most frequent during the months of July, August, and September when an average of 3 tropical cyclones/month are generated. During the same period, the yearly average of tropical cyclones that actually crossed or made landfall in the country is nine (9), roughly half of the annual average of tropical cyclone generated. October, November, and September are the leading months of the greatest frequency of tropical cyclone passage, averaging at least 1 tropical cyclone hit per month. The eastern part of the country's northern half, from the Batanes islands in the north down to the Bicol peninsula and Samar (Fig. 2), experiences the most frequent passage of tropical cyclones. PAGASA records indicate that the top five most tropical cyclone-visited provinces are Batanes, Cagayan, Quezon, Aurora, and Kalinga-Apayao (PAGASA, 2005b). In contrast, tropical cyclones only occasionally pass through central and western Mindanao. Gusty winds, torrential rains, strong waves, storm surges, and associated flooding provide the destructive power of tropical cyclones. OCD/NDCC (undated) shows that tropical cyclones from 1970 to 2005 have killed more than 20,000 persons, affected over 19 million families, and destroyed properties worth about P150 billion. Table 1 lists the most destructive tropical cyclones in the country since 1970 with damages exceeding P 3 billion. Interestingly, tropical storm Uring which triggered the infamous Ormoc flood of November 5, 1991 that killed nearly 3,000 of its residents (and 2,000 elsewhere) and left over 2,900 houses in the city completely destroyed was not among the most powerful cyclones (maximum wind speed of 95 kph) or the most devastating in terms of total damages (P 1.044 billion). (De Leon and Laigo, 1993; PAGASA, undated1; OCD/NDCC, undated1).

Floods and landslides

Among environmental hazards, flooding is widely regarded as the most common, afflicting poor and rich countries alike (Blaikie et al., 1994; Smith, 1996). Floods, put simply, are events where more water is delivered to a basin that it can readily absorb or store. Such definition allows the triggering events for excess water to be classified as natural *or* man-made; but the underlying causes for many basins' inefficient absorption and storage capacity often combine natural and man-made factors. Natural trigger for floods, for instance, include heavy rainfall, lake breakouts, storm surges, tsunamis, and high tides; in contrast, dam failures and intentional releases

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[2] On the basis of equivalent wind speeds, typhoons are equivalent to Category 1 Hurricane (119-153 kph) on the Saffir-Simpson Hurricane scale (National Weather Service, 2005). Typhoons reaching > 241 kph are equivalent to Category 4 Hurricane (210-249 kph) and are sometimes called "super typhoons". Of course, there is no equivalence in terms of destructiveness of typhoons and hurricanes as this depends on local factors of affected regions.

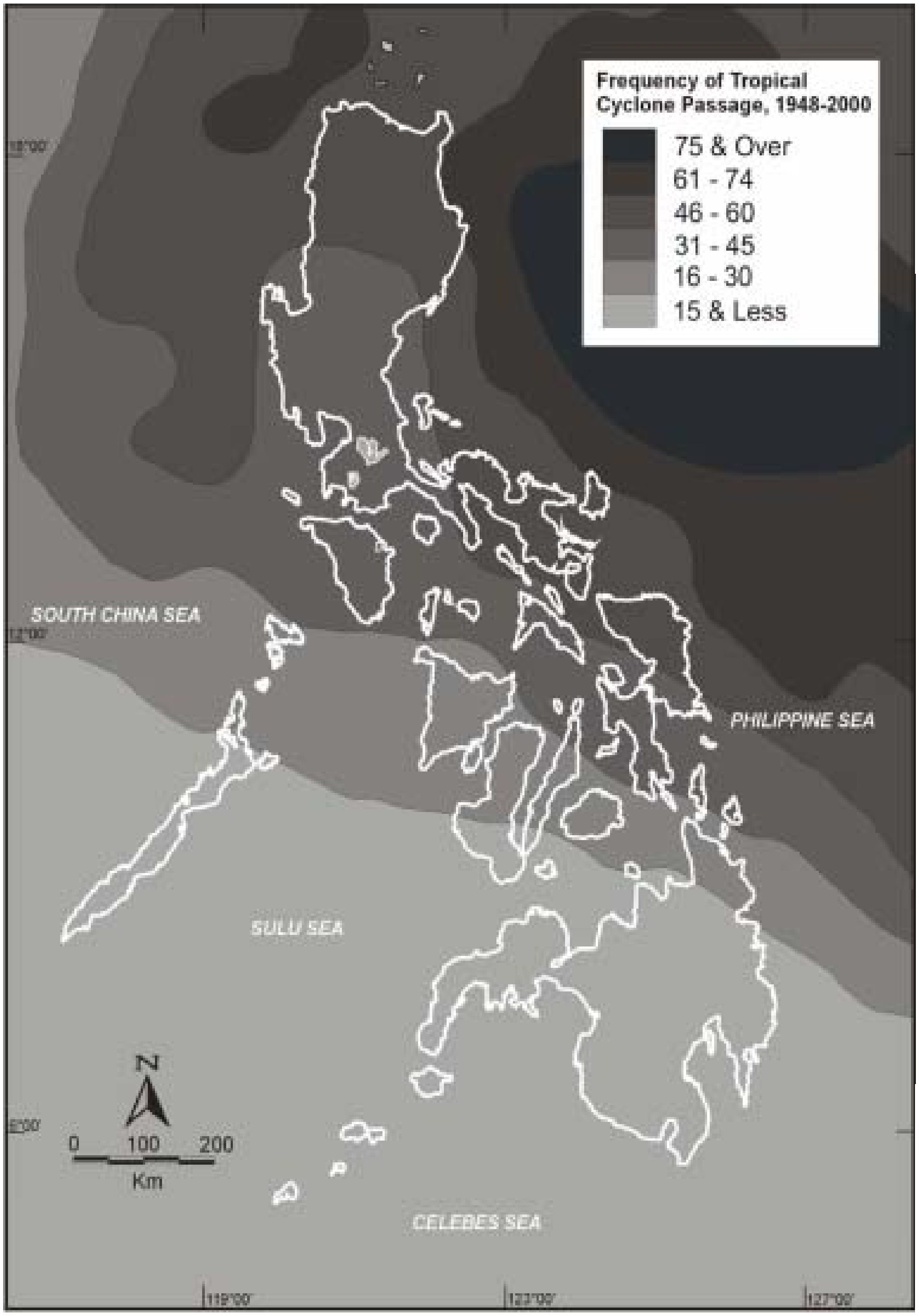

Figure 2. Tropical Cyclone Paths

Name	Date	Max. Wind (kph)/Location	Regions Affected	Killed	Families Affected[2]	Houses Destroyed[3]	Total Damage (P billion)[4]
1. Nitang	31Aug-4Sep84	220 - Surigao	IV, VI, VII, VIII, X, & XI	1,029	278,488	108,219	3.913
2. Unsang	21-26Oct88	215 - Virac	All except CAR, IX, XII,	157	537,152	38,932	5.636
3. Ruping	10-14Nov90	205 - Mactan	All except I, II, CAR & ARMM	508	1,010,004	222,026	10.846
4. Trining	24-31Oct91	150 - Tuguegarao	CAR, I, & II	83	105,317	8,070	3.719
5. Kadiang	30Sep-7Oct93	100 - Casiguran	NCR, CAR, I, II, III, & IV	126	415,813	2,249	8.752
6. Rosing	30Oct-4Nov95	255 - Virac	NCR, CAR, I, II, III, IV, V, & VIII	936	960,777	225,872	10.799
7. Gading[5]	16-21Sep98	110 - Dagupan	NCR, CAR, I, II, III, & IV	108	335,699	10,900	3.794
8. Loleng	15-25Oct98	95 - Casiguran	CAR, I, II, III, IV, V, VI, & VIII	303	910,912	96,581	6.787
9. Iliang	11-16Oct98	125 - Tuguegarao	CAR, I, II, III, IV, & V	46	268,468	26,305	5.375
10. Reming	25Oct-1Nov00	100 - Sangley Point	NCR, CAR, I, II, III, IV, V, VI, & VIII	114	486,400	16,910	3.944
11. Feria	2-5July01	90 - Aparri	All except ARMM, VII, XI, XII	188	415,436	12,774	3.586
12. Unding[6]	14Nov-3Dec04	122 - San Jose	NCR, CAR, I, II, III, IV, V, VI & VIII	1,068	731,730	42,119	7.615

[1] Tropical cyclone data (name, date, max. wind) from 1970-1993 from PAGASA (undated1); data from 1994-2005 from PAGASA (various years).

[2] Affected means a situation where livelihood means or houses, or both, are lost or partially/completely destroyed

[3] Refers to totally destroyed dwellings only.

[4] Nominal Peso, from OCD/NDCC (undated1).

[5] Effects of prior Typhoon Emang (16-17Sept98) are included by OCD/NDCC.

[6] Effects of Typhoon Unding (14-21Nov), Storm Violeta (22-26Nov), Depression Winnie (28-30Nov) and Typhoon Yoyong (30Nov-3Dec) are lumped together.

Table 1. List of Most Destructive Tropical Cyclones

of reservoir water constitute artificial triggers. Floods are also classified as *riverine floods* if they overtop natural or artificial banks of rivers, *coastal floods* if they swamp communities close to shores, and *flashfloods* if they occur in narrow valleys and heavily developed and poorly drained urban areas (Smith and Ward, 1998).

In the Philippines, as in many other areas, excessive rainfall is by far the most important flood trigger. Annual rainfall in the country varies from <2,000 mm (western and central Philippines) to >4,000 mm (eastern Philippines) with a mean value of 2,379 mm (PAGASA, 2001a; undated2). Rainfall patterns in the country are affected by three major wind systems – tropical cyclones, monsoons, and linear systems such as the intertropical convergence zone (ITCZ). During the southwest monsoon season from May to September, the country's western sections receive more than 900 mm of rain (PAGASA, 2001b). On the other hand, heavy rainfall drenches the country's eastern section from October to March due to the combination of the northeast monsoon season and the peak of the tropical cyclone season. In addition, the ITCZ affects the country from May to October bringing widespread cloudiness, scattered precipitation, and moderate to strong winds (PAGASA, 2001a). These rainfall patterns combine with topography to make certain regions of the country particularly flood-prone (Figure 3). Among these are Cagayan valley, Central Luzon, parts of metropolitan Manila, Calapan plain, Bicol river valley, Panay plain, Agusan valley and Cotabato valley (PAGASA, undated2; Zoleta-Nantes, 2000). It is not surprising that the most flood-prone parts of the country are large river basins and alluvial plains.

Due to the nearly year-long abundant rainfall in many parts of the Philippines, flooding is a frequent environmental disaster. Drowning, uprooting of houses, and inundation of agricultural farms are among the most common direct effects of floods. From 1980 to 2005, 524 flood events unrelated to tropical cyclones were recorded in the country causing 1,550 fatalities and damages worth P13.17 billion. (OCD/NDCC, undated2; 2006). Table 2 lists the years with the most destructive flood occurrences that are not typhoon-related. No

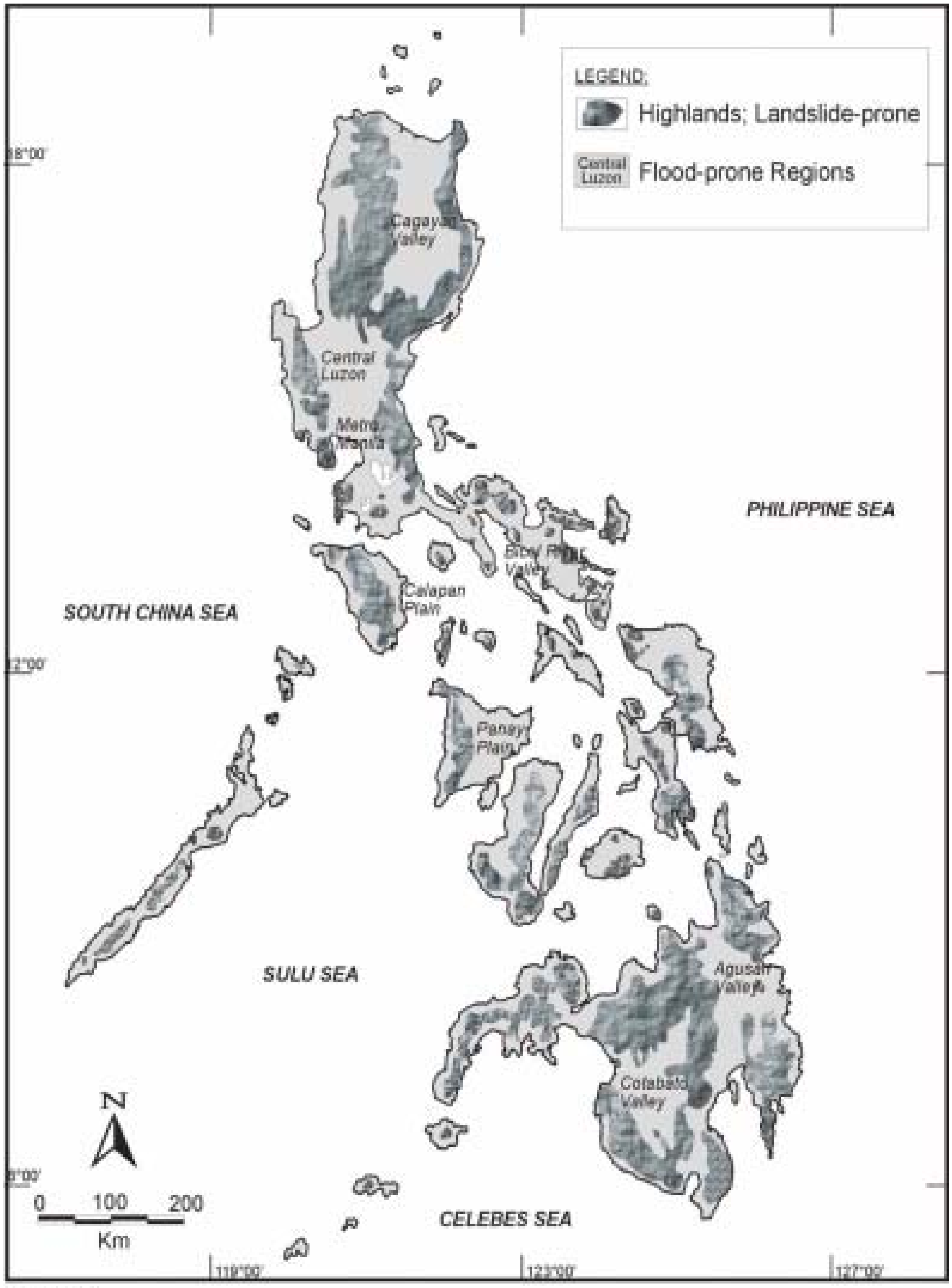

Figure 3. Flood-Prone Regions in the Philippines

region of the country is immune from floods, and even the mountainous Cordillera Administrative Region (CAR) experiences destructive flooding. But data from Table indicate that it is Mindanao, especially Regions X, XI, and XII that have been especially frequented by destructive floods.

The causal link between rainfall and floods also ties floods with another major hazard – landslides. Although landslides are also triggered by earthquakes and many types of human activities, landslides in the country are more prone during the wet season. Water seeps through rock layers, lubricating the soil until the grains slide past one another and initiating the mass wasting process in many steep slopes. This process can range from the slow and almost imperceptible movement of rock masses known as *creep*, to the highly visible shower of debris termed *rock falls*, and to the classic *landslide* where a large block of earth detaches from its formation and glides down a slope dumping a mass of soil, mud, and rock debris at its foot (Leet et al., 1978).

Year	Number of Occurences	Regions Affected	Killed	Families Affected	Houses Destroyed	Total Damage (P billion)
1. 1980	5	mr*	336	126,528	530	0.366
2. 1989	13	mr	101	81,152	25	0.392
3. 1993	26	III, VIII, IX, X, XI, XII, ARMM	32	72,997	274	1.085
4. 1994	32	NCR, I, III, IV, VI, VII, IX, X, XI, XII	42	62,485	443	0.340
5. 1995	56	II, IV, V, VI, VII, IX, X, XI, XII, ARMM	127	185,588	350	1.306
6. 1997	28	NCR, I, CAR, II, III, IV, VI, IX, X, XI, ARMM, CARAGA	46	75,882	590	1.108
7. 1999	38	NCR, I, CAR, II, III, IV, V, IX, X, XI, XII	282	672,638	3,742	2.181
8. 2000	45	II, VI, IX, X, XI, XII, CARAGA	49	168,678	587	1.673
9. 2001	27	VI, IX, X, XI, XII, ARMM, CARAGA	60	129,732	1,226	1.446
10. 2002	26	NCR, III, VI, VII, IX, X, XI, XII, ARMM. CARAGA	44	272,924	1,032	1.511
11. 2003	43	I, VI, VII, X, XI, XII, ARMM, CARAGA	21	137,638	733	0.646
12. 2005	28	NCR, CAR, III, IV, V, VI, VII, VIII, XI, XII	27	337,704	53,973	0.317

[1] Data from OCD/NDCC (undated2; 2006) except data on regions affected from 1993-2001 taken from DSWD-DROMIC (various years).

*mr - missing records

Table 2. List of Years with Most Destructive Floods, 1980-2005

The mountainous regions of the country depicted in Figure 3 are broadly coincident with the "high-danger zone" for landslides mapped by Arboleda (1992) and shown in PHIVOLCS (2002a). Their steep slopes combined with the high rainfall in the country and the added danger posed by earthquakes make these regions highly prone to landslides. But even the lowlands – often population centers – that are deemed low-risk based on geologic grounds may rate higher when man-made activities that increases the risk for slope or ground instability are considered. Due to such setting, disasters arising from landslides are fairly common phenomenon. Nonetheless, the incidence and destructive power of landslides in the country are less than those of typhoons and floods. From 1980 to 2005, OCD/NDCC (undated2; 2006) recorded 199 destructive landslides resulting in 883 deaths and nearly P 227 million in property damages. Table 3 lists the years between 1980 and 2005 with the most destructive landslide occurrences. Apparently, OCD/NDCC did not treat the numerous landslides from the July 1990 Luzon earthquake as independent events but rather as part of the July 1990 earthquake. A cursory examination of the incomplete landslides data reveals that since the 1990s the mountainous Davao region (XI) has been the site of some of the most destructive landslides in the country (Table 3).

Volcanic eruptions

In areas where tectonic plates collide, volcanoes form above subsurface regions of melting produced when one plate is subducted (or underthrusted) along oceanic trenches beneath another plate. The Philippine archipelago is surrounded by subduction zones on nearly all sides marked by the Philippine Trench in the East, the Manila Trench and

Year	Number of Occurences	Regions Affected	Killed	Families Affected	Houses Destroyed	Total Damage (P million)
1. 1981	6	mr*	1	38	mr	22.000
2. 1982	5	mr	mr	167	15	24.000
3. 1984	4	mr	18	7	5	1.210
4. 1985	5	mr	64	25	mr	0.054
5. 1986	3	mr	mr	30	mr	12.000
6. 1993	7	NCR, VIII, XI	41	244	110	8.697
7. 1995	13	IV, XI	20	522	15	92.000
8. 1996	12	V, VI, VII, XI, CARAGA	13	71	49	1.163
9. 1999	12	III, VII, XI	42	1,107	123	3.683
10. 2003	14	CAR, V, VII, XI, XII	170	2,634	32	41.690
11. 2004	17	CAR, IV, V, VI, VII, X, XI, CARAGA	34	5,418	85	25.720
12. 2005	15	CAR, NCR, IV, V, VII, VIII	11	441	73	10.32

[1] Data from OCD/NDCC (undated; 2006) except data on regions affected from 1993-1999 taken from DSWD-DROMIC (various years).
*mr - missing records

Table 3. List of Years with Most Destructive Landslides Between 1980-2005

Negros-Sulu Trench in the west, and the Cotabato Trench in the south (Fig. 4). This tectonic configuration produces five major Quaternary (those formed since about 1.8 million years ago) volcanic belts in the country. The eastern Philippine arc runs from the Bicol peninsula in the north down through Leyte and eastern Mindanao. The western Luzon arc starts from the Batanes and Babuyan islands in the north, through central Luzon, and southward into Mindoro and Marinduque. The volcanoes in Negros island comprises the Negros arc while the northeast-trending chain of volcanoes from the Sulu islands, through Basilan and eastern Zamboanga peninsula constitute the Sulu arc. Finally, the line of volcanoes distributed north-south from Camiguin island, through Bukidnon, and south to Balut island forms the Central Mindanao arc.

For hazard purposes, PHIVOLCS (2002b; 2005a) classifies Philippine volcanoes into three categories: *active*, *potentially active*, and *inactive*. Active volcanoes are those that have historical eruptions known through written accounts or oral traditions. Potentially active volcanoes, though without historic eruptions, emit volcanic exhalations or have erupted during the past 10,000 years, and inactive volcanoes lack indications of any geologically recent (within the past 10,000 years) activity.[3] Of the country's more than 300 volcanoes believed to be Quaternary age, 22 are classified by PHIVOLCS (2002b; 2005a) as active – 12 in Luzon, 8 in Mindanao, and 2 in the Visayas (Figure 5).[4] Of the active volcanoes, six are regarded as particularly destructive and are under constant PHIVOLCS monitoring through manned observatories – Mayon, Taal, Bulusan, and Pinatubo in Luzon, Kanlaon in Negros island, and Hibok-Hibok in northern Mindanao. The eruptive frequencies of active Philippine volcanoes are highly variable but consistent with those reported for "average" active volcanoes worldwide, ranging from one eruption in 220 years (Walker, 1974) to one every 5 years (Simkin and Siebert, 1981). For example, Mayon volcano, the country's most active, has had an eruption every about 8 years since its first recorded eruption in 1616 while Taal's repose period is roughly 12 years since 1572 (PHIVOLCS, 2005b).[5] In contrast, Pinatubo's eruption in 1991 was its first in more than 500 years (Newhall et al., 1996) while Parker volcano (Fig. 5) has not erupted in over 360 years since its cataclysmic explosion in January 1641 (Delfin et al., 1996)). In terms of frequency therefore, volcanic eruptions occur much less often than tropical cyclones. But the danger from volcanoes is no less insignificant because of the various types of hazards that emanate from them.

Hazard directly associated with an erupting volcano include lava flows, dome growth, lateral blasts, pyroclastic flows, ash-falls, lahars, and volcanic gases (Blong, 1984; PHIVOLCS, 2005a). Indirect hazards from eruptions include lahars, secondary pyroclastic flows, landslides, ground subsidence, fissuring, tsunami, and hydrothermal explosions. Even when not erupting, however, volcanoes pose hazards in the form of crater-lake breakout, landslides, lahars, and toxic volcanic gases. Most of the eruption hazards cited above have been documented in many Philippine eruptions and explain why such events, though less frequent than other natural hazards, are equally destructive.

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[3] Classification of volcanoes using this system is naturally dependent on the state of knowledge of each volcano rather than on the volcano's true magmatic condition. As more data become available, a previously "inactive" volcano like Leonard Kniassef in Davao del Norte classified as inactive in early PHIVOLCS catalogue is upgraded to active status in PHIVOLCS (2002).

[4] Active volcanoes in Luzon are: 1) Babuyan Claro (Cagayan), 2) Banahaw (Laguna & Quezon, 3) Bulusan – (Sorsogon), 4) Cagua (Cagayan), 5) Camiguin de Babuyanes (Cagayan), 7) Didicas (Cagayan), 8) Iraya (Batanes), 9) Iriga (Camarines Sur), 10) Mayon (Albay), and 11) Pinatubo (Zambales, Tarlac, Pampanga). Active volcanoes in Mindanao are: 1) Bud Dajo (Sulu), 2) Hibok-Hibok (Camiguin), 3) Leonard Kniaseff (Davao del Norte), 4) Makaturing (Lanao del Sur), 5) Matutum (South Cotabato), 6) Musuan (Bukidnon), 7) Parker (South Cotabato), and 8) Ragang (Lanao del Sur & Cotabato). 1) Kanlaon (Negros Occidental) and 2) Biliran (Biliran) are the active volcanoes in the Visayas. PHIVOLCS (2002; 2005a).

[5] Repose periods of Taal and Mayon are calculated from frequency of eruptions over recorded history for both volcanoes taken from PHIVOLCS (2005b).

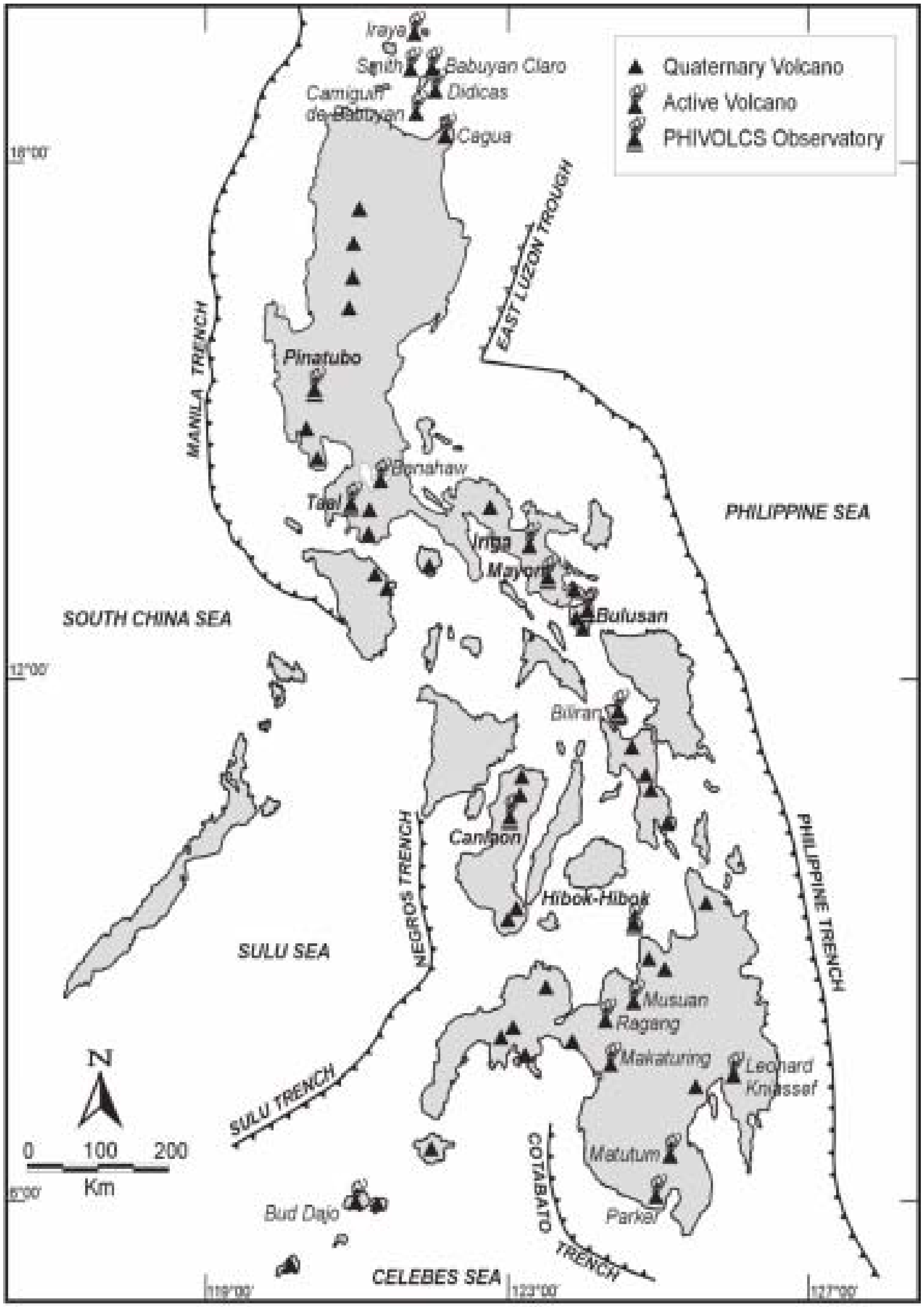


Fig. 4. Trenches and Volcanic Arcs in the Philippines

To measure the relative size or magnitude of an explosive eruption, American volcanologists Christopher Newhall and Stephen Self devised a volcanic explosivity index (VEI). The index is a 0-to-8 scale, somewhat analogous to the Richter scale, in that each number represents a factor 10 increase in eruptive power based on combined qualitative descriptions of the eruption (which vary with eyewitnesses' position and observation skills) and measurable factors like height of eruption column, volume of ash ejected, area affected, and eruption duration (Newhall and Self, 1982). The world's strongest volcanic eruption witnessed so far was the April 10, 1815 eruption of Tambora volcano in Indonesia with a VEI of 7 (Smithsonian Institution, 2005). The 1883 Krakatau and the 1991 Pinatubo eruptions both have VEI 6 rating.

Table 4 lists the country's most destructive volcanic eruptions since 1900. Only twelve major volcanic eruptions have occurred in the country in over a century causing about 2,500 deaths, the destruction of 44,000 houses and damages worth nearly P13 billion. Unlike the impacts of typhoons, floods, and landslides that are fairly distributed throughout the Philippines, the bulk of eruption disasters are associated with just four volcanoes – Taal, Hibok-Hibok, Mayon and Pinatubo. Moreover, the extent of the impact is highly variable – from a few households during Mayon's 1984 eruption to six provinces in central Luzon during Mount Pinatubo's 1991 eruption.

Eruption	**Date**	**VEI**[2]	**Areas Affected**	**Killed**[3]	**Families Affected**[4]	**Houses Destroyed**[4]	**Total Damage (P Billion)**[4]
1. 1911 Taal	Jan. 30, 1911	4	Volcano Island & 6 towns to the west	1,335	nr	nr	nr
2. 1950 Hibok-hibok	Sep 15, 1950	3	Barrio Ilihan, north of volcano	68	nr	nr	nr
3. 1951 Hibok-Hibok	Dec. 4-6, 1951	3	Mambajao town, north of volcano	~500	nr	nr	nr
4. 1965 Taal	Sep. 28-30, 1965	4	Volcano Island, Taal Lake	190	nr	nr	nr
5. 1968 Mayon	Apr 20-May 20, 1968	3	Legaspi City & 5 Albay towns	1	nr	110*	nr
6. 1984 Mayon	Sep 9-Oct. 6, 1984	3	Legaspi City, Sto Domingo, Camalig	0	12,465**	253**	0.085***
7. 1991 Pinatubo	Jun 8-15, 1991	6	6 provinces in Region III	310	249,371	40,867	11.475
8. 1992 Pinatubo	Jul 7-Dec 9, 1992	1	Pampanga, Tarlac, Zambales	28	164,408	3,281	1.232
9. 1993 Mayon	Feb 2-Apr 4, 1993	3	8 towns in Albay province	80	21,600	nr	0.073
10. 1996 Kanlaon	Aug 10-Sep 3, 1996	1	Summit region	3*	20	0	0.000
11. 2000 Mayon	Feb 23-Mar 7, 2000	3	4 towns in volcano's south sector	0	13,290	0	0.090
12. 2001 Mayon	Jun 23-Jul 26, 2001	3	Legaspi City & 5 Albay towns	1**	11,259	0	0.049

[1] Events, dates, and affected areas of destructive eruptions taken from: PHIVOLCS (undated); OCD/NDCC (undated1); Alcaraz et al. (1952); Blong (1984); Anonymous (1996); DOST-PHIVOLCS (1996; 2001); PHIVOLCS (2000).

[2] VEI data from Smithsonian Institution (2005); Newhall, C.N. (pers. comm., 2006).

[3] Count of direct fatalities taken from same sources as 1; *mountaineers killed near summit, **infant death in evacuation center (Anonymous, 2001)

[4] Data from OCD/NDCC (undated1) and DSWD-DROMIC (1996) except*Anonymous (1968); ** MSSD (undated); ***Tayag et al. (undated).

nr - no exact record

Table 4. List of Most Destructive Volcanic Eruptions, 1900-2005

Earthquakes

The feeble to violent ground motion that occurs during earthquakes is related to tectonic movements in the earth's crust although earthquakes may also happen during volcanic unrest and eruptions. Tectonic quakes of intermediate (70-300 km) and deep (300-700 km) origin are caused by the movement of tectonic plates; shallower tectonic earthquakes (0-70 km) are either plate-related or due to slips along faults – breaks or zones of weaknesses in rock formations along which clear displacement had occurred. Earthquake strength is measured in two ways – by the calculated *magnitude* of the energy released at its origin (focus) and by the felt *intensity* of motion produced on the surface directly above the focus (epicenter) and beyond. Magnitude (M) is often reported using the open-ended Richter scale, with each whole number on the scale representing a ten-fold increase in the amplitude of seismic wave but a 30-times increase in seismic energy released from the preceding scale number (PHIVOLCS, 2002a; USGS, 2005a). Earthquakes with magnitude of 2.0 or less, termed microearthquakes, are hardly felt by people but are detected instrumentally. Magnitude 4.5 earthquakes are strong enough to be felt over a wide area and might even cause local damage. Several scales are used to measure relative intensity including the modified Mercalli (I –XII) and the Rossi-Forel original (I-X) and adapted (I-IX) scales; I on these scales typically represent a scarcely perceptible ground motion while the highest number signifies complete devastation. In 1996, a PHIVOLCS earthquake intensity scale (PEIS) (I-X) was devised but earthquake intensities of past Philippine quakes are often reported in either original or modified Rossi-Forel scale (PHIVOLCS, 2002b; 2005c).

The hazards associated with earthquakes include ground shaking, surface rupturing, landslides, liquefaction, and tsunamis. While ground shaking naturally accompanies all large earthquakes, the occurrence of other hazards depends on the geographic setting of the event. For instance, liquefaction – where water-saturated sediments are expelled from the subsurface due to compaction during earthquake – is more likely in coastal plains, deltas, and marshes; landslides are more frequent in hilly terrains where steep slopes or freshly cut surface make the ground unstable.

The Philippines experiences at least five earthquakes per day (PHIVOLCS, 2002a). The epicentral distribution of earthquakes in the country since 1900 with at least M 7 magnitude is shown in Figure 5. This pattern clearly shows that large (indeed most) earthquakes in the country are fairly well distributed throughout the archipelago with most generated off-shore coincident with the oceanic trenches (Fig. 5). Off-shore quakes are particularly prevalent in the southern segment of the Philippine Trench east of Mindanao and Samar where an average of 16 "perceptible" earthquakes occur annually (PHIVOLCS, 2002a). Other seismically active off-shore regions are those immediately east of northern Luzon, west of Ilocos, around Mindoro, and west of Mindanao. In contrast, Palawan and its surrounding seas are seismically quiet (Fig. 5).

Apart from the oceanic trenches, active faults on land are major earthquake generators in the country. Besana et al (2000) defined active faults in the Philippines as those that have evidence of movement within the last 10,000 years based on historical (ca AD 1599) documentation of movement and seismicity as well as dated geological units disrupted by faults or produced as a consequence of fault movement. Without doubt, the most important active fault is the Philippine Fault that runs 1,200 km in a north-northwesterly fashion from Mindanao in the south to northern Luzon (Fig. 6). Average movement along the fault is about 2.5 centimeter per year in a left-lateral fashion and releases the stress brought about by opposing movement of the Philippine and Eurasian plates that sandwich the archipelago (Aurelio et al, 1994). The seismicity of the Philippine Fault is diffused along its many segments and numerous large historic earthquakes have been attributed to it, including the intensity IX November 30, 1645 earthquake that leveled Manila claiming 3,000 victims, the M 7.0 1973 Ragay Gulf earth-

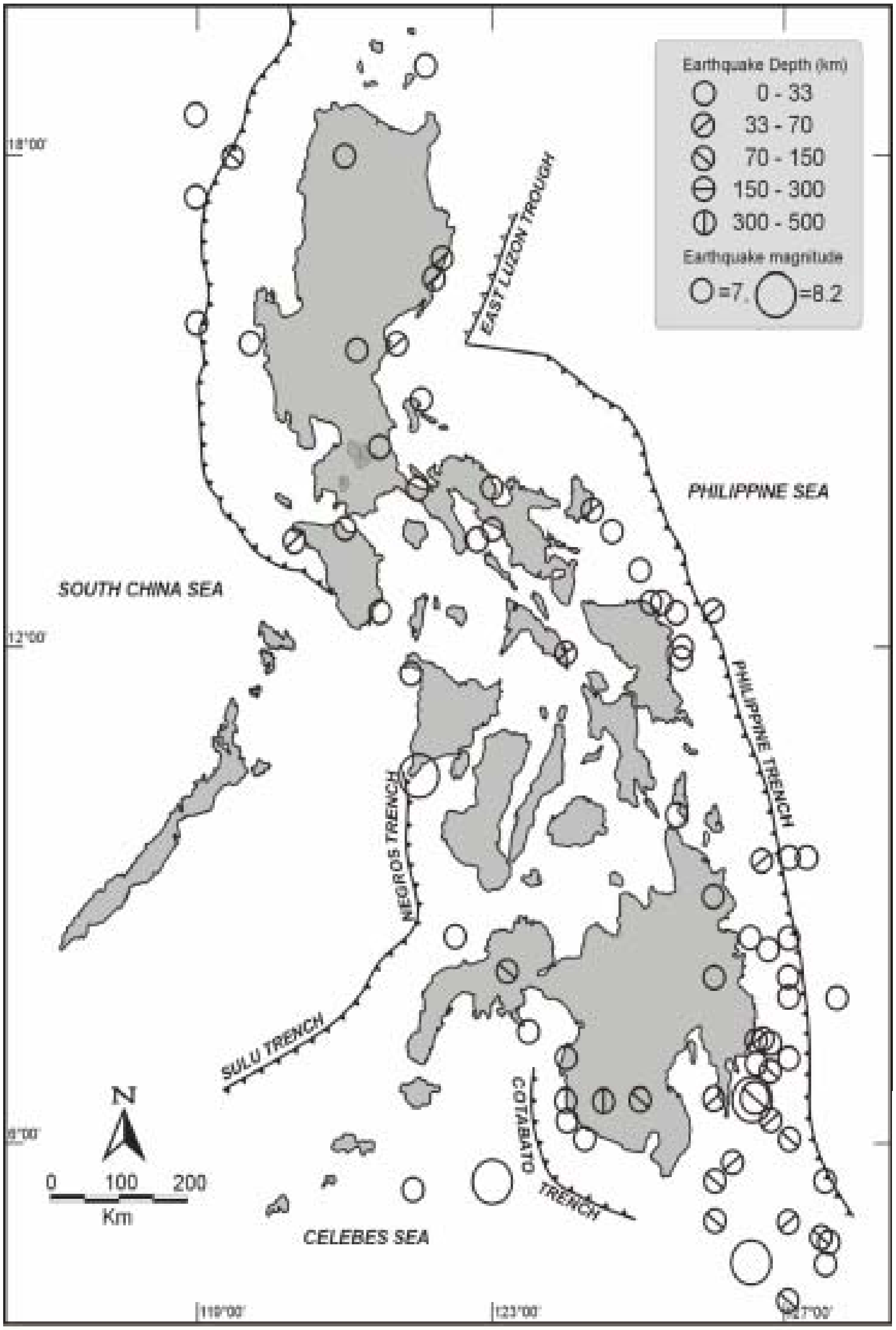


Fig. 5. Philippine earthquakes M ≥7.0 since 1900

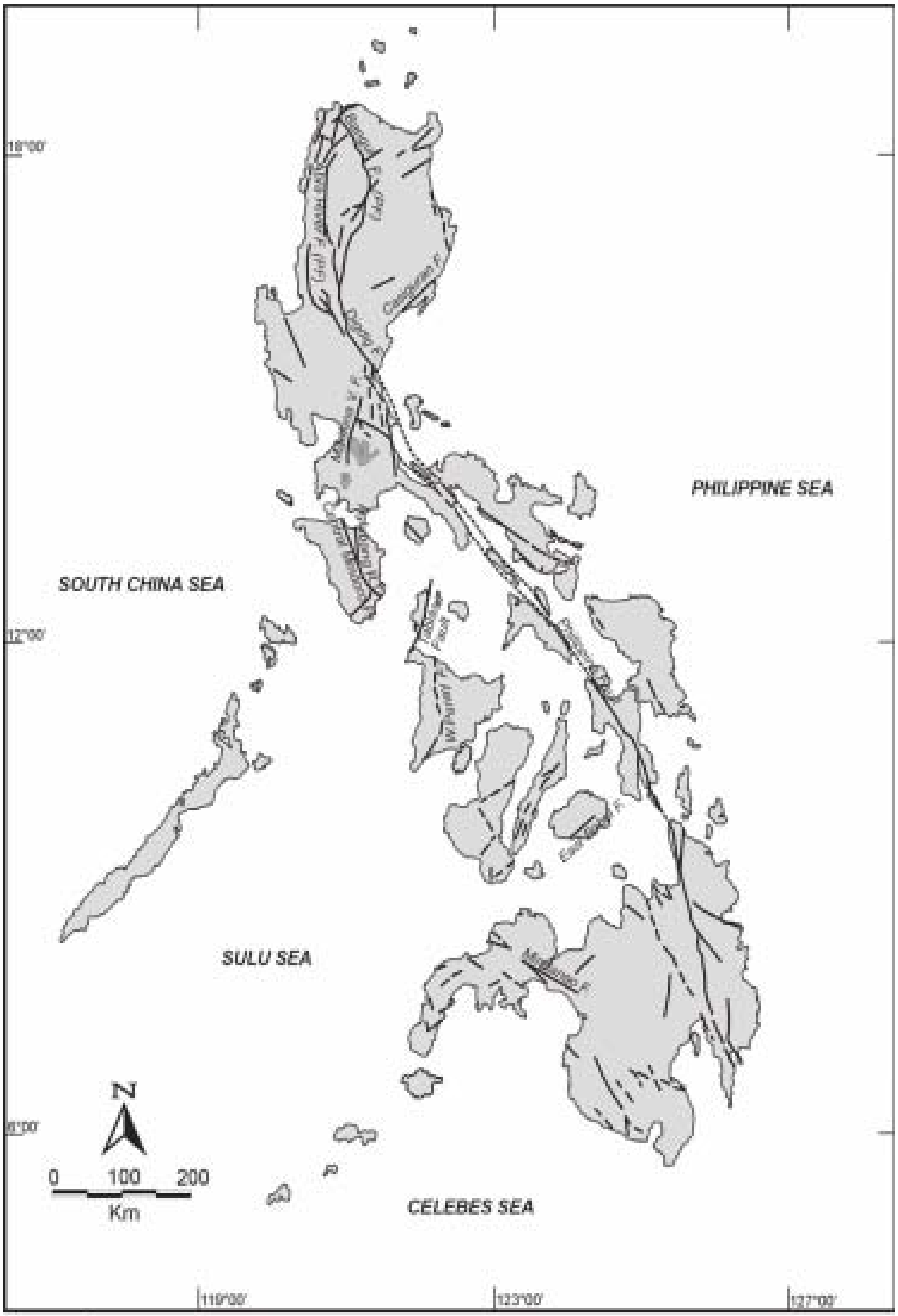


Fig. 6. Major Active Faults in the Philippines

quake, and the M 7.8 July 16, 1990 Luzon earthquake (SEASEE, 1985; Bautista et al, 1992). Other active faults in the country with associated historical seismicity include the Casiguran Fault in Quezon (M 7.3 August 2, 1968), the Aglubang Fault in northern Mindoro (M 7.1 November 15, 1994), and the Tablas Fault in Tablas island and western Panay (M 8.3 January 25, 1948) (PHIVOLCS, 2002a).

Table 5 lists the twelve most destructive Philippine earthquakes since 1970, all of which have M 6 or higher. The distribution of these major tremors in all three island groups reflect the pattern in Figure 7 and highlights the idea that, except for Palawan, no part of the country is free from the devastation of powerful earthquakes. The variations in damages are largely a combined function of the magnitude and the setting of the event. For example, two of the most devastating earthquakes – the 1976 Moro Gulf (P 2.47 Billion) and the 1994 Mindoro earthquakes (P0.51 Billion) –both with > M 7.0, were triggered offshore, and generated tsunamis that swept nearby coastal communities. The most devastating earthquake thus far – the M 7.8 July 1990 Luzon earthquake (P 18.7 Billion) – had an on-shore epicenter in Central Luzon close to many highly populated urban centers.

Tsunamis

Tsunamis are sea waves caused by ocean floor disturbances most often related to submarine earthquakes and less frequently to volcanic eruptions and submarine landslides. A substantial displacement of huge areas of the

Name	Date	Magnitude	Highest Intensity (RF)/ Location	Killed	Families Affected	Houses Destroyed	Total Damage (P Billion)
1. 1970 East Luzon	7-Apr-70	7.3	IX - Baler, Quezon	14	nr	nr	nr
2. 1973 Ragay Gulf	17-Mar-73	7.0	VIII - Calauag, Quezon	14	nr	98	nr
3. 1976 Moro Gulf[2]	17-Aug-76	7.9	VII - Cotabato City, Jolo (Sulu)	5,729[3]	60,356	60,356	0.864
4. 1983 Laoag[4]	17-Aug-83	6.5	VII - Laoag City	19	1,654	117	0.015
5. 1990 Luzon	16-Jul-90	7.8	VIII - Rizal, Nueva Ejica	1,283	227,918	25,207	12.225
6. 1990 Bohol	8-Feb-90	6.8	VIII - Jagna, Duero (Bohol)	6	7,000	182	0.154
7. 1990 Panay	14-Jun-90	7.1	VII - Culasi, Antique	8	nr	nr	0.300
8. 1994 Mindoro[5]	15-Nov-94	7.1	VII - Baco, Oriental Mindoro	83[6]	22,452	1,530	0.180
9. 1999 Manila	12-Dec-99	6.5	VI - Manila, Olongapo	6	87	29	0.333
10. 2002 Palimbang	6-Mar-02	6.8	IX - Palimbang, Sultan Kudarat	8	15,430	133	1.320
11. 2003 Masbate	15-Feb-03	6.2	VIII - Masbate	4	531	16	0.090
12. 2003 Samar	19-Nov-03	6.6	VI - Borongan, Eastern Samar	1	2,872	15	0.310

[1] Data taken from PHIVOLCS (2002a; 2005d), OCD/NDCC (undated1), DSWD-DROMIC (various years).

[2] Damages data (families affected, houses destroyed, and total damage) exclude those from associated tsunami.

[3] Fatalities include those listed as missing in 1976.

[4] Data on fatalities, families affected, and houses destroyed from MSSD (undated).

[5] Damages data exclude those from associated tsunami.

[6] Direct casualty from earthquake is 29. Death toll (54) from tsunami constitute 65% of all fatalities.

nr - no exact record

Table 5. List of Most Destructive Earthquakes in the Philippines, 1970-2005

ocean floor and their overlying column of water is required to trigger a tsunami. Earthquake-generated tsunamis are associated with events with magnitude of more than 6.5 on the Richter scale, and two-thirds of the most damaging tsunamis in the Pacific have been associated with earthquakes of M 7.5 or greater (Bryant, 1991). In its open-ocean source, the height of the tsunami wave is generally less than a meter, small enough to go unnoticed by passing ships, but its wavelength can exceed a kilometer (Blong, 1984; Bryant, 1991). Because of these shallow but long-wave features, tsunamis do not lose much energy fighting gravity and can therefore travel at very high speeds reaching as much as 800 km/h. As a tsunami approaches shallower waters close to land, the rising seabed acts as brake on the on-coming wave, forcing it to slow down but also raising its wave height until it forms a wall of water that slams the coast. The more sudden the change in seabed slope towards the shore, the more energy is released upon impact. In Japan, Shuto (1993) showed tsunami height to average around 3 m for 160 reported events though a few reached as high as 25 m. Contrary to popular belief, however, tsunamis' destructive power is often less related to their wave heights than to the strong currents and floating debris during their run-up and run-down over the coasts (USGS, 2005c).

Given that not all submarine earthquakes generate tsunamis, tsunami occurrence is a much rare event than other natural hazards. But the speed of tsunamis' travel across oceans, the vast expanse of areas that they can impact at once, and the fury with which they inundate coastal communities make the devastation from this rare event especially dramatic. Tsunamis' awesome power was most recently and vividly demonstrated by the December 26, 2004 Indian Ocean tsunami triggered by the M 9.0 earthquake off the western Sumatran coast. The trail of destruction covered 10 countries in Southeast Asia to East Africa killing more than 283,000 and displacing over a million people, making this the worst recorded tsunami in history (USGS, 2005d). In Banda Aceh near the earthquake epicenter, tsunami wave heights and run-up distances exceeded 30 m, leaving a third of the city's 320,000 residents dead or missing (Sumatra International Tsunami Survey Team, 2005).

The Philippines, once again, lies in the most tsunami-struck region of the world – the western Pacific stretching from Russia's Kamchatka peninsula in the north down to Japan and the Philippines through Indonesia and Papua New Guinea (Bryant, 1991). Most of the tsunamis in this region originate locally; of the 109 damaging tsunamis of the past century, only 9 were triggered by sources outside the region. Nonetheless, non-local sources of tsunamis may still cause considerable impact in the country. For instance, a tsunami triggered by an earthquake in the west coast of the Americas can reach the eastern part of the Philippines in 16 hours while a tsunami generated by an earthquake in Japan will be felt within 3 hours (PHIVOLCS, 2002a).

Much of the tsunami threat in the Philippines, however, originates locally as many active earthquake generators exist within archipelagic waters. The parts of the country facing the greatest threat from tsunami, according to PHIVOLCS, are shown in Figure 7. Except for some segments in the northeast, south, and the eastern Bicol coasts, much of Luzon faces high tsunami potential. In central Philippines, areas with high tsunami hazard include the eastern shores of Mindoro, Tablas and Burias islands, the northern coasts of Samar, the eastern coasts of Panay including Guimaras island, Leyte's west central coasts, the central part of Cebu's eastern shores, and the northern shores of Bohol. Much of Mindanao also has high tsunami potential, except for the northern coasts between the two Misamis provinces and the southcentral coasts around Davao Gulf.

Between 1627 and 1994, 31 earthquake-generated tsunamis have been recorded in the country based on historical accounts and instrumental data (PHIVOLCS, 1993; PHIVOLCS Quick Response Team, 1994). Because majority of these events occurred prior to the 1970s and lack monetary estimates of damages, the basis of selection of the most destructive ones are number of fatalities and houses destroyed. Where these data are also

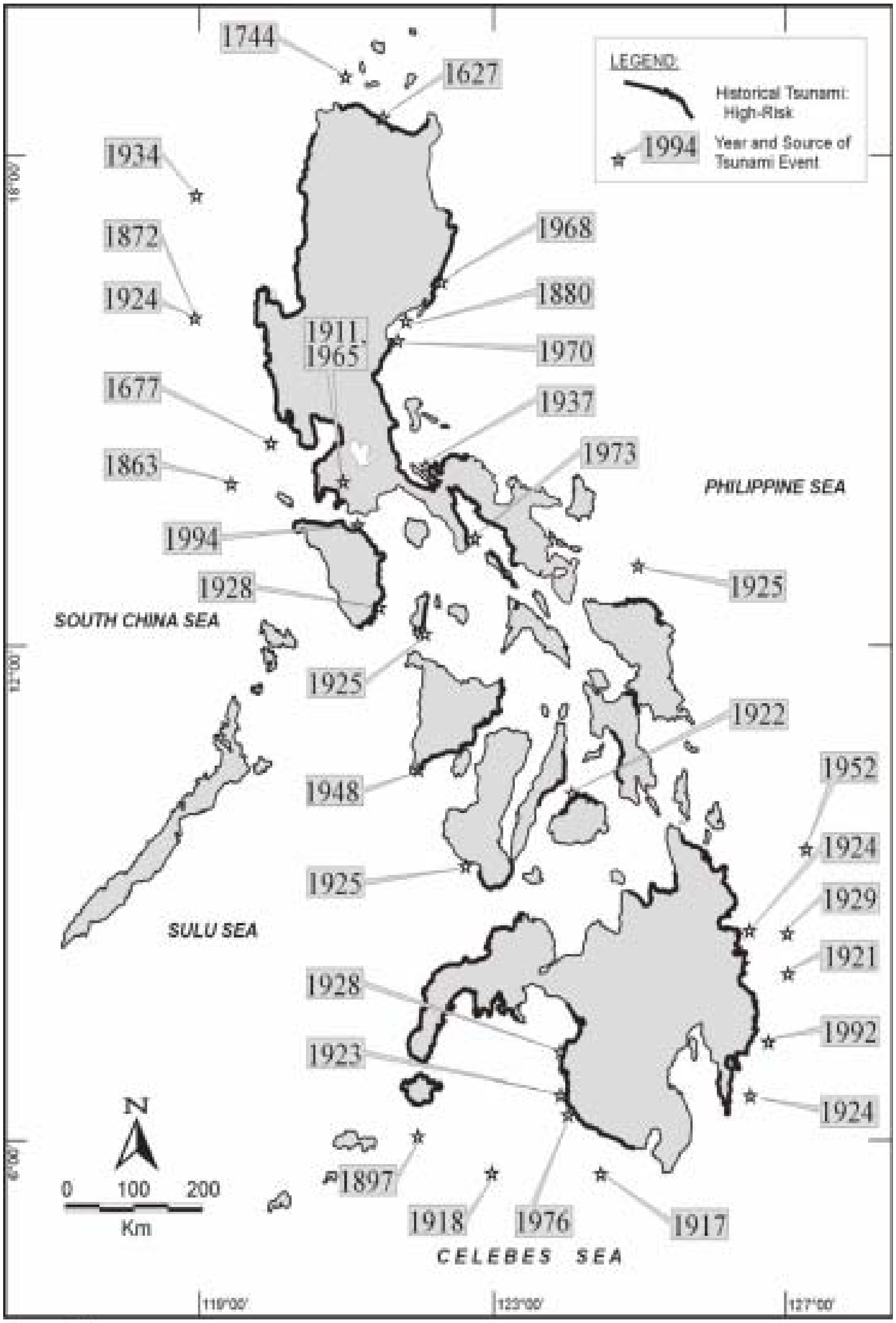


Fig. 7. Tsunami-prone regions of the Philippines

missing, the qualitative descriptions of wave effects summarized in SEASEE (1985) are used. Based on these grounds, Table 6 lists twelve tsunami events considered the most destructive. All are earthquake-generated except two tsunamis spawned by the 1911 and 1965 eruptions of Taal volcano (Moore et al., 1966; Blong, 1984). Six of the twelve most destructive tsunamis in the country took place in Mindanao. The most devastating occurred on August 16, 1976 when a M 7.9 earthquake in the Moro Gulf sent 6-7 m high waves crashing on the southwest coasts of Mindanao killing at least 3,000 people, injuring more than 8,000 and leaving over 10,000 families homeless.

Droughts

In its most simple definition, a drought is a prolonged period with minimal precipitation. Although the concept

Date	Earthquake (Magnitude)	Areas Affected	Wave Height (m)	Run-Up Distance (m)	Persons Killed	Houses Destroyed	Total Damage (P Billion)
1. Sept 1627	nr	Bangui, Segovia, Cagayan	nr	4000(?)	nr	nr	nr
2. June 3, 1863	nr	Manila, Cavite	"topped deck of ships"	nr	~320	1,170	nr
3. Sept. 21, 1897	8.2	Zamboanga, Jolo, Basilan	6 - 7	nr	nr	nr	nr
4. Jan. 30, 1911	Taal eruption	Taal Lake and lakeshore towns	nr	~350	~270[2]	nr	nr
5. Aug. 15, 1918	8.0	Glan, Balut and Sarangani islands	2 - 8	nr	~100	nr	nr
6. Apr. 15, 1924	7.7	Mati, Davao	nr	nr	nr	nr	nr
7. Dec. 19, 1928	7.5	Cotabato and Zamboanga del Sur	nr	nr	93	"hundreds"	nr
8. Jan. 25, 1948	8.2	Iloilo Strait	nr	nr	2	nr	nr
9. Sept. 28, 1965	Taal eruption	Taal Lake	>4	80	~40[3]	nr	nr
10. Aug. 17, 1976[4]	7.9	Western and southern Mindanao	6 - 7	nr	3,723	39,231	1.606
11. May 17, 1992	7.3	Caraga, Banganga, Surigao	4	nr	2[5]	20[5]	nr
12. Nov. 15, 1994[6]	7.1	Mindoro Oriental	2-8.5*	200-250	54	994	0.334

[1] Data from Blong (1984); PHIVOLCS (1993;2002a); PHIVOLCS Quick Response Team (1994); SEASEE (1985) except where noted.
[2] Based on USGS (1999) estimate that 20% of total fatalities in 1911 eruption was from tsunami.
[3] Fatalities reflect balance from 190 total fatalities in eruption, 150 of which died from base surges (see Blong, 1984).
[4] Damages (killed, houses destroyed, total damage) are estimated at 65% of total earthquake losses following ratio of tsunami/total fatalities in 1994 Mindoro event.
[5] Fatalities and houses destroyed from DSWD-DROMIC (1992).
[6] Damages (houses destroyed, total damage) are estimated at 65% of total earthquake losses reported.
*corresponds to vertical run-up distance.; nr – no exact record.

Table 6. List of Most Destructive Tsunamis in the Philippines, 1627-2005

of a water deficit contained in this definition is correct, it oversimplifies a phenomenon involving other climatological factors such as air temperature and relative humidity, regional and hemispheric weather patterns, and time-scales (McNab and Karl, 2003). Reduced precipitation as a drought signal, for instance, must occur during periods when substantial rain is expected but fails to fall. In addition, droughts are often associated with higher than normal surface air temperature even during summer months. And finally, not only is rainfall minimal and the temperature higher during droughts but the air is usually dryer than usual. Naturally, these conditions will be propagated on the different stages of the hydrological cycle and depending on which stage is affected, different drought terms are applied. *Meteorological droughts* refer to periods of lower-than-usual rainfall, *hydrological droughts* to conditions when levels in natural water reservoirs such as rivers, lakes, and aquifers fall below normal, and *agricultural droughts* to cases when soil moisture is too low that crop harvests fail (Smith, 1996). *Famines* are extreme forms of agricultural droughts when food security has been severely devastated that large segments of the population can no longer maintain their normal healthy existence. Of course, what is considered "normal" or "usual" for these conditions will vary with localities using historical statistical trends.

Although droughts may have various natural and man-made origins, a particularly important climatological factor for some countries such as the Philippines is the El Niño- Southern Oscillation (ENSO) phenomenon. Under normal conditions, easterly trade winds from the west coasts of South America push warm water westward across the Pacific. In the western South American coasts, the departing warm ocean water is replaced by upwelling cold water from depths resulting in dry and cold surface conditions. In the western Pacific and East Asia, the arriving warm waters bring in tropical cyclones and monsoon rains. Every two to 9 years, this pattern in atmosphere-ocean interplay in the Southern Pacific shifts – the southern oscillation – but because the true cause of the shift is not known for certain, the timing of the oscillation cannot be predicted accurately. What is known, however, is that around Christmas time in South America, the normally cold ocean waters in the western coasts are replaced by warm currents that temporarily bring in heavy fish catch, the phenomenon originally dubbed by Peruvian fishermen as "El Niño" – Spanish for the Christ Child. Although its cause is still debated, the sudden weakening of the easterly trade winds in this region allows warm water usually driven to the western Pacific to return east, depriving East Asia of its monsoon rains but drenching the western coasts of South America with torrential downpours. Once established, an ENSO event typically lasts until the first half of the following year and sometimes longer. In some instances, El Niño is followed by a cold phase – La Niña – that brings even lower temperature in normally cold climes and more rainfall in rain-drenched regions (Mock, 2004; PCARRD, 2001).

Given its location in equatorial Pacific, the Philippines is subject to extreme climate variability related to ENSO. Climatic indicators of ENSO in the country include delayed onset and early termination of the rainy season, weak monsoon activity, and weak tropical cyclone activity (PAGASA, 2001a; Jose, 2004) although Anglo (1999) cautioned that ENSO's typhoon-related signals in the country vary with the strength of specific ENSO episodes. Naturally, prolonged dry-spells and drought are still the best indicators of ENSO. The parts of the Philippines most susceptible to ENSO-drought spells (Manila Observatory , 2005) are depicted in Figure 8. Mindanao and Central Visayas face the greatest risks for ENSO-related droughts. In particular, the ARMM region and the provinces on the western flank of Davao Gulf are rated to have "very high" risk to El Niño while the rest of Mindanao, Negros, Cebu, and Bohol are all considered "high" risk for El Niño drought.

Unlike other rapid-onset disasters whose impacts are immediately recognizable, the effects of ENSO-related droughts take time to build. Moreover, such effects embrace both environmental (soil degradation, deteriorated groundwater quality, and increased forest fires) and socio-economic (poor agricultural output, water- and heat-related diseases, reduced hydroelectric power output, and increased trans-migration) factors. These traits make

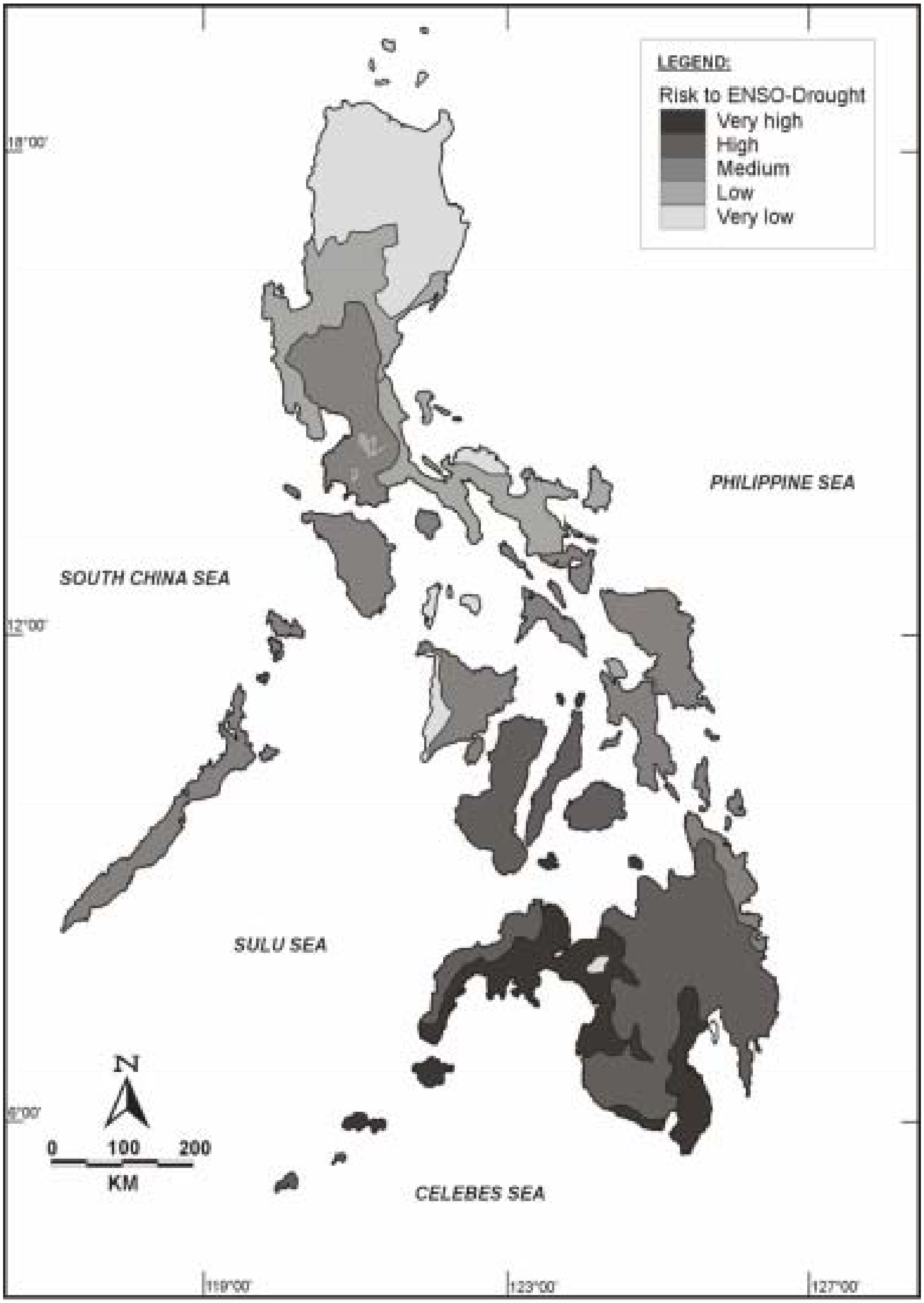


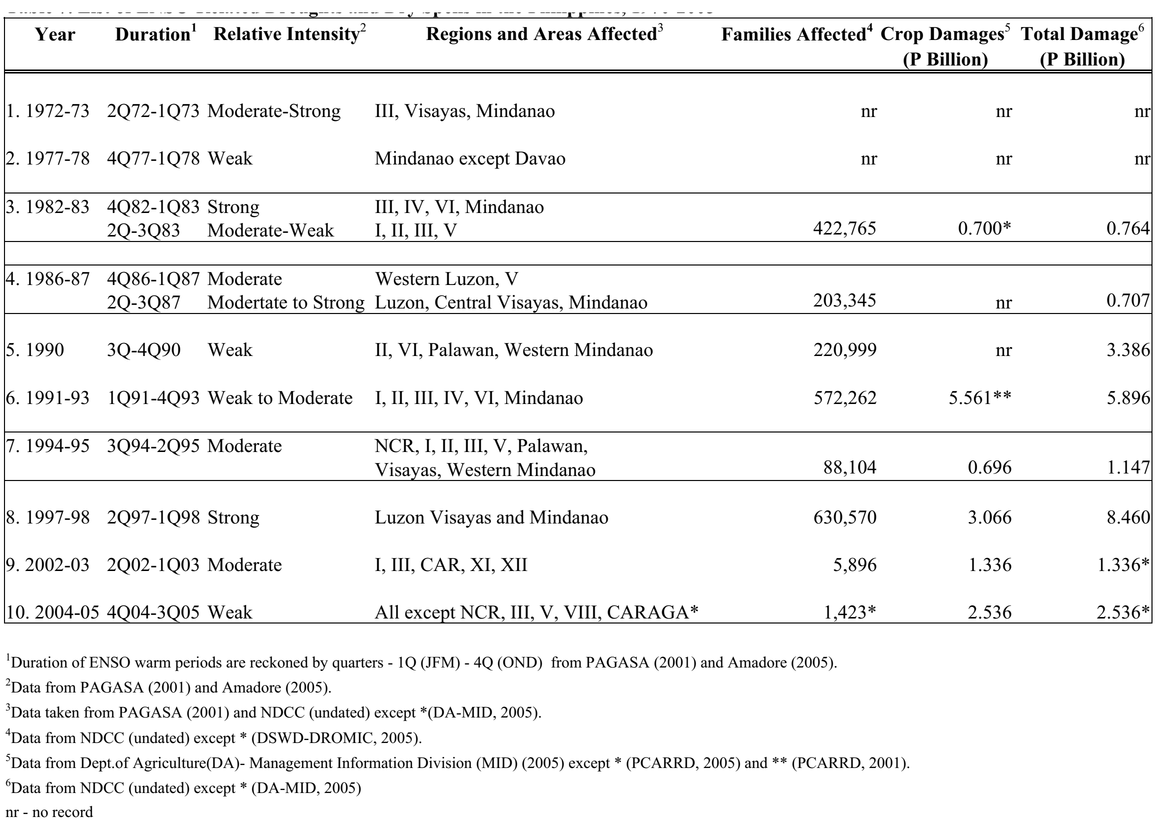
Fig. 8. ENSO-drought prone regions of the Philippines

it much more difficult to provide an exact accounting of drought damages compared to other more visible and rapid-onset disasters.

Since 1970, PAGASA has recorded 10 ENSO-related drought spells in the country [Table 7]. Readily apparent from this table is that ENSO-droughts have become much more frequent in the 1990s (2-year average recurrence interval) compared to the 1970s and 1980s (~4-year interval). Total damages from these events are in the order of P24 billion, an underestimate given the lack of corresponding costs for droughts in the 1970s. Nonetheless, the magnitude of the losses and the fact that the entire country is affected by droughts (with varying severity per location) make droughts among the most insidious environmental threats facing the Philippines.

Pest infestations

Major outbreaks of pest infestations that afflict agro-ecosystems in the country, particularly rice and corn



Year	Duration[1]	Relative Intensity[2]	Regions and Areas Affected[3]	Families Affected[4]	Crop Damages[5] (P Billion)	Total Damage[6] (P Billion)
1. 1972-73	2Q72-1Q73	Moderate-Strong	III, Visayas, Mindanao	nr	nr	nr
2. 1977-78	4Q77-1Q78	Weak	Mindanao except Davao	nr	nr	nr
3. 1982-83	4Q82-1Q83	Strong	III, IV, VI, Mindanao			
	2Q-3Q83	Moderate-Weak	I, II, III, V	422,765	0.700*	0.764
4. 1986-87	4Q86-1Q87	Moderate	Western Luzon, V			
	2Q-3Q87	Modertate to Strong	Luzon, Central Visayas, Mindanao	203,345	nr	0.707
5. 1990	3Q-4Q90	Weak	II, VI, Palawan, Western Mindanao	220,999	nr	3.386
6. 1991-93	1Q91-4Q93	Weak to Moderate	I, II, III, IV, VI, Mindanao	572,262	5.561**	5.896
7. 1994-95	3Q94-2Q95	Moderate	NCR, I, II, III, V, Palawan, Visayas, Western Mindanao	88,104	0.696	1.147
8. 1997-98	2Q97-1Q98	Strong	Luzon Visayas and Mindanao	630,570	3.066	8.460
9. 2002-03	2Q02-1Q03	Moderate	I, III, CAR, XI, XII	5,896	1.336	1.336*
10. 2004-05	4Q04-3Q05	Weak	All except NCR, III, V, VIII, CARAGA*	1,423*	2.536	2.536*

[1] Duration of ENSO warm periods are reckoned by quarters - 1Q (JFM) - 4Q (OND) from PAGASA (2001) and Amadore (2005).

[2] Data from PAGASA (2001) and Amadore (2005).

[3] Data taken from PAGASA (2001) and NDCC (undated) except *(DA-MID, 2005).

[4] Data from NDCC (undated) except * (DSWD-DROMIC, 2005).

[5] Data from Dept.of Agriculture(DA)- Management Information Division (MID) (2005) except * (PCARRD, 2005) and ** (PCARRD, 2001).

[6] Data from NDCC (undated) except * (DA-MID, 2005)

nr - no record

Table 7. List of ENSO-related Droughts & Dry-Spells in the Philippines, 1970-2005

fields, can be traced to three leading agents – diseases, insects, and rodents. Among diseases, bacterial leaf blight (BLF), rice blast (BL), and tungro (TU) are especially worrisome. In young seedlings, bacterial leaf blight turns leaves into yellow until the whole seedling dies while in more mature plants, the disease makes the panicle (grain) sterile or unfilled without stunting plant growth (IRRI, 2004a). Caused by the bacteria *Xanthomonas oryzae* pv. *oryzae*, bacterial leaf blight is promoted by high temperatures, high humidity, rainy weather and excessive nitrogen application (IRRI, 2004a). Similarly, the rice blast disease caused by the fungus *Mangaporthe grisea* Barr often occurs under high humidity and wetness darkening rice leaves and grains (IRRI, 2004b). Perhaps the most destructive of rice diseases in the Philippines and Southeast Asia is tungro (TU), a viral disease spread by the green leafhopper (GLH) insect that causes severe plant stunting and yellowing of leaves (IRRI, 2004c; Truong et al., 1999).

Insects other than GLH are also prominent pests in Philippine farms. Various types of caterpillars, for example, pose as hazards under different conditions. Caterpillar larvae called armyworms (AW) thrive on dry land feeding on rice at any stage of the plant (IRRI, 2003a) while stem borers (SB) are caterpillars that live on rice stems causing the center leaves to turn brown and die or attacking rice panicles and turning them white (IRRI, 2003b). Rice bugs (RB) belonging to the genus Leptocorisa infest fields with a particularly offensive odor (IRRI, 2003c). Adult species of these rice bugs are only 15 mm long and 3 mm wide and they inflict damage by sucking out the contents of developing grains. Two species of planthoppers (PH) are also major farm hazards, the brown variety (*Nilaparvata lugens* (Stal)) and the white-backed variety (*Sogatella furcifera* (Horvarth)), because they turn leaves into brown, transmit stunt diseases, and are able to disperse for hundreds of kilometers (IRRI, 2003d). For many of these insects, population explosions that lead to pest infestations are often due to environmental factors – climatic variations, destructions of their natural predators by insecticides, or introduction of favorable plant hosts (IRRI, 2003d; Smith, 1996).

The two main rodent pests (RT) are the ricefield rats (*Rattus argentiventer*) and the Black rat (*Rattus rattus*) (IRRI, 2004d). As its name suggests, ricefield rats are associated with rice crop planting; they give birth to 10-14 young before panicle initiation and stop when the crop ripens. In contrast, black rats are post-harvest problems because they thrive around houses and grain stores; the females give birth to only 6-10 young but some breed for most of the year (IRRI, 2004d).

From 1991 to 2005, records from the Department of Agriculture's Bureau of Agricultural Statistics indicate that at least 176 individual pest outbreaks have occurred in the country (Table 8) (BAS, 2005; various years). Damage from pest infestations is almost entirely in the form of losses in rice and corn production although four deaths – two in 1998 and two in 2004 – were reported by OCD/NDCC, it is unclear what the nature of these deaths was with respect to farm pests. Total damages from pests during the said period amounted to nearly P 2 billion. When analysis is confined to the period 2002-2005 where detailed damage data exist, rats, bacterial leaf blight and brown plant hoppers are the three most destructive farm pests; regions XI (particularly South Cotabato and Sarangani), XII (North Cotabato), V (Camarines Sur), and II (Cagayan) received the brunt of destructive pest infestations. Pests identified by OCD/NDCC (undated1) as "locusts" responsible for outbreaks in 1994, 1996, and 1997 (Table 8) are likely to be various types of plant hopper (E. Moreno, pers. comm., 2006).

Health epidemics

A disease is widely acknowledged to be a form of environmental or, more specifically, biological hazard because of its strong potential to cause epidemics when the vector (virus, bacteria or parasite) spreads to human

Year	No. of Outbreak	Kind of Pests[2]	Regions or Areas Affected	Families Affected	Prod. Losses (metric tons)	Total Damage (P million)
1. 1991	3	nr	Misamis Occid., N. Cotabato, S. Kudarat	505	1,763	8.638
2. 1992	2	nr	Bukidnon (X), Maguindanao (ARMM)	133	665	3.049
3. 1993	1	nr	Agusan Sur (CARAGA)	142	200	0.838
4. 1994	5	Locust	III, X, XII, CARAGA	353	9,119	51.804
5. 1995	11	nr	I, II, III, VI, IX, X, CARAGA	nr	2,231	15.963
6. 1996	9	Locust	I, VI, IX, X, XI, XII	nr	32,439	267.461
7. 1997	21	Locust	I, II, III, V, VI, IX, X, XI, XII, ARMM, CARAGA	192*	22,714	176.685
8. 1998	25	RT	I, III, IV, V, VI, IX, X, XI, XII, ARMM, CARAGA	nr	71,970	576.589
9. 1999	24	nr	I, II, V, VI, VII, IX, X, XI, XII, CARAGA	26	51,710	439.999
10. 2000	21	RB	II, III, V, VI, VII, VIII, X, CARAGA	2,342	23,367	200.415
11. 2001	12	RB	II, V, VI, VIII, IX, XI, XII, ARMM, CARAGA	nr	2,677	19.960
12. 2002	11	RT, RB, TU	II, III, IV, V, VI, XI	nr	1,114	8.499
13. 2003	7	RT, TU, RB, BL, BLB, AW	II, V, VI, VIII, XI, XII	113	15,252	125.698
14. 2004	6	RT, RB, TU, BLB, PH, SB	XI, XII, ARMM	1,304**	4, 953	67.504
15. 2005	18	RT, SB TU, BLB, RB, AW, PH	V, VI, IX, X, XII, CARAGA	nr	8,603	81.500

[1] Data from DA-Bureau of Agricultural Statistics (2005; various years) except for "persons affected", "families affected" and "kind of pests" (pre-2002) taken from OCD/NDCC (undated1) and DSWD-DROMIC (various years).

[2] RT -rat, RB - rice bug, TU -tungro, BL - rice blast, BLB-bacterial leaf blight, AW-armyworm, PH-plant hopper or brown plant hopper, SB-stem borer

*2 dead in Zambales; **2 dead in South Cotabato

Table 8. List of Pest Infestations in the Philippines, 1991-2005

population lacking immunity (Blaikie et al., 1994; Smith, 1996). In many instances, health epidemics are themselves triggered by other environmental disasters that cause community disruption and the concentration of huge numbers of people in a limited area. But poverty is generally seen as the more predisposing factor in outbreaks of infectious diseases; malnutrition, lack of hygiene, crowded living conditions, dirty water, inadequate solid waste disposal facilities, and lack of access to health care all contribute to health epidemics (Smith 1996, p. 244). It is therefore no surprise that health disasters have been more prevalent in poor and developing countries. The World Health Organization (WHO), for instance, reports that malaria causes at least one million deaths annually worldwide, 90% of which occur in Sub-Saharan Africa killing an African child every 30 seconds (WHO, 2005a). Eighty-two percent of the 530,000 annual deaths due to measles occur in Africa (48%) and Southeast Asia (34%) (WHO, 2005b). Dengue and dengue hemorrhagic fever (DHF), which prior to 1970 occurred in only 9 countries, is now endemic in more than 100 countries causing 50 million cases every year with southeast Asia and the western Pacific the most seriously affected (WHO, 2002). On top of these traditional health hazards, poor and rich countries alike suffer from epidemics related to newer diseases such HIV/AIDS, SARS, avian influenza, Ebola virus, and bovine spongiform encephalopathy ("mad cow" disease).

In the Philippines, the most frequent causes of health epidemics are those linked to poor living conditions such as diarrhea, cholera, malaria, measles, dengue, and meningococcemia (DOH, 2006; WHO, 2005c). For instance, a common environmental factor for dengue and malaria is transmission through mosquitoes, *Aedes* *aegypti* for dengue and *Anopheles* mosquitoes for malaria (WHO, 2002; 2005a). But while Aedes mosquito is a predominantly urban species that breeds in crowded areas, different species of Anopheles mosquitoes are able to adapt and thrive in a wide variety of land-use and human settlement patterns (Patz et al., 2000; WHO, 2002). Both measles and meningococcemia have no known animal reservoir but are instead transmitted through person-to-person contact; measles is carried by a virus that afflicts the back of the throat and the lung while meningococcal meningitis is spread by the bacterium *Neisseria meningitidis* that lodges in the brain and spinal cord (DOH, 20005a; WHO, 2003; 2005b). In both diseases, transmission is usually through airborne droplets of respiratory secretions facilitated by close interpersonal contact; young children especially those lacking immunization are especially susceptible to measles infection. Although not directly linked with person-to-person transmission, cholera is also highly correlated with poverty because it is spread by contaminated water and food. Caused by the bacterium *Vibrio cholerae* found in brackish water where it is associated with algal blooms, the disease is an acute intestinal infection characterized by watery diarrhea and vomiting that can lead to severe dehydration and death (WHO, 2000).

Three of the above diseases – diarrhea, malaria, and measles – are amongst the top ten leading causes of morbidity in the Philippines from 2000 to 2002. Diarrheal diseases often occupy the top spot with a morbidity rate of about 1,000/100,000 population; malaria (~50/100,000) and measles (~30/100,000) are 8th and 10th causes, respectively (DOH, 2006). Equally significant, in 2000 (the latest year for which data are available), diarrheas and measles constitute the third and fourth leading cause of child mortality for ages 1-4, respectively while diarrhea was the fifth leading cause for children ages 5-9 (DOH, 2005b).

Records on health outbreaks are scattered between DOH and DSWD-DROMIC but the latter contains data on number of families affected and a proxy of the financial damage in terms of assistance provided by local and national governments to victims. Thus, the DSWD data set are used to generate the list of health outbreaks in the country from 1992 to 2005 (Table 9). At least 54 outbreaks of infectious diseases have been tallied during this period resulting in over 900 deaths affecting over 8,000 families. The financial cost of more than P8.6 million is likely to be a considerable underestimate because it does not include medical expenditures and lost earnings of affected population. Table 9 affirms that cholera, malaria, measles, dengue and meningococcemia are the leading disease agents of epidemics in the country. Central (XII) and eastern Mindanao (XI, CARAGA) appear to be the most vulnerable to health-related disasters.

"Technological accidents"

Disasters arising more directly from modern human activities including fires, airplane crashes, sea mishaps, building collapse, poisoning, armed insurgencies, etc. classified by OCD/NDCC as "man-made" and referred here as "technological accidents", occur with numbing frequency in the country. For example, in a one-month period in early 1996, three major accidents occurred; on February 18, the inter-island ferry *Gretchen I* sank in central Visayas killing more than 50 passengers, followed two weeks later by the collapse of a mine tailings pond in Marinduque island affecting over 2,000 families, and on March 18, a nighttime fire in Quezon City's Ozone Disco killed more than 150 young people (OCD/NDCC, undated1). Whether due to human error, poor government regulations, or "acts of God", technological accidents, big and small, are a staple of media reports, public outcries, and congressional investigations.

From 1991 and 2005, 2,754 cases of "man-made" disasters in which 6,534 persons were killed, over 3.6 million families affected, and P 22 billion in properties were recorded (OCD/NDCC undated1). This statistics

Year	Disease	Number of Outbreaks	Regions or Areas Affected	Killed	Families Affected[2]	Assist. Extended (P thousands)
1992	?	1	Region XI	23	207	11.00
1994	Cholera	1	T'boli, South Cotabato	304	317	0.00
1995	?	1	Nakar, Quezon	10	42	108.00
1996	Measles	6	Davao City, Davao Oriental, South Cotabato	46	795	542.90
		1	Benguet	3	98	0.00
	Malaria	1	Agusan del Norte	5	47	31.77
1998	Malaria	1	Siasi, Sulu	134	696	2,000.00
	?	1	McArthur, Leyte	7	66	50.00
2001	Measles	1	Maco, Sarangani	14	42	10.00
	?	1	Region VIII	10	144	18.85
2002	Measles	3	Davao del Norte, South Cotabato	15	261	522.95
2003	?	1	Cabadbaran, Agusan del Norte	20	14	24.92
	SARS	1	Alcala, Pangasinan	2	169**	
2004	?	2	Region XI	0	1,535	487.73
	Meningococcemia	3	Baguio City, Mt. Province, Ifugao***	21	nr	nr
2005	Meningococcemia	3	Baguio City, Mt. Province, Ifugao***	51	nr	4,700.00
	Dengue	22	All regions (acute in NCR, VII, X, XI)	249	3,712	0.00
	Diarrhea	2	Region V	11	217	108.57
		1	Palawan (IV)	22	50	nr
	Malaria	1	Region XII	5	134	0.00

[1] Data from DSWD-DROMIC (various years) except where noted; * from Vanzi (1998); ** from Macaraeg (2003); *** from Manila Times (2005); Palangchao (2005); WHO (2005c).

Table 9. Selected Health Epidemics in the Philippines, 1992-2005

indicate that technological accidents can be regarded as "everyday" disasters, with one fatality and P4 million lost each day. The twelve most destructive of these events, in terms of fatalities and families affected, are given in Table 10. Seven of these events are transportation-related, three are linked to mass movements (mine tailings, landslides, and garbage) and two are caused by fires.

That five of the seven deadliest transportation-related disasters in the country between 1991 and 2004 involved water-borne transport (Bocaue Pagoda, *MV Ferry Cebu City*, *MV Viva Antipolo*, *MV Princess of the City*, and *Superferry 14*) underscores two important things: the heavy reliance on inter-island shipping transport in the Philippines and the continuing dismal safety record of Philippine sea transport. In other words, high vulnerability together with significant maritime hazard makes sea-borne traffic disasters fairly common *and* deadly events. Because travel by inter-island vessels and ferries remains the cheapest, sometimes the only, mode of long-distance transport for many Filipinos, it is a "no-brainer" that improving the seaworthiness of such vessels is the key to reducing accidents. But despite a history of horrific sea mishaps, none worse than the December 20, 1987 sinking of the *MV Dona Paz* due to a collision with an oil tanker off Mindoro island in which over 4,300 people perished – the worst peacetime maritime accident in the world (BBC News, 1998) – the local shipping industry and government regulators are unable to make significant progress in promoting maritime safety. Unless vessel overloading, aging facilities, inadequate crew training, and poor safety compliance are systematically and

Name	Date	Nature and Site of Disaster	Killed	Families Affected	Properties Destroyed
1. Bocaue Pagoda Boat Tragedy	Jul 2, 1993	Boat sinking during fluvial parade, Bocaue River, Bulacan	274	nr	Floating pagoda
2. MV Ferry Cebu City	Dec 2, 1994	Collision of passenger ship and oil tanker, Manila Bay	140	117	Passenger ship
3. MV Viva Antipolo VII	May 16, 1995	Fire and sinking of wooden ferry near Lucena	62	270	Wooden ferry
4. Marcopper Spill	March 3, 1996	Spill of 3 million cubic meters of mine tailings on Boac River, Marinduque	0	2,185	Boac River and coastal areas
5. Ozone Disco Fire	Mar 18, 1996	Nighttime fire in crowded disco, Quezon City (Q.C.)	156	nr	Building
6. Cebu Pacific 387	Feb. 2, 1998	Crash of passenger plane in Mt. Sumagaya, Mindanao	104	104	DC-9 aircraft
7. MV Princess of the Orient	Sep 18, 1998	Sinking of passenger ship in stormy seas off Cavite	150	nr	13,935-ton ship
8. Cherry Hills Landslide	Aug 3, 1999	Landslide in housing subdvision, Tanay, Rizal	58	125	160 houses
9. AirPhilippines 541	April 19, 2000	Crash of passenger plane in Samal island, Mindanao	131	131	Boeing 737 aircraft
10. Payatas Tragedy	July 10, 2000	Trashslide & fire in Payatas garbage dump, Q.C.	224	680	100 houses
11. Manor Hotel Fire	Aug 18, 2001	Nightime fire in hotel, Quezon City	75	nr	Hotel building
12. Superferry 14	Feb. 27, 2004	Terrorist bombing and sinking of passenger ship off Corregidor Island, Manila Bay	116	899	10,192-ton ship

[1] Data come principally from two sources: OCD/NDCC (undated1) and DSWD-DROMIC (1993-2004). Supplemental information comes from the folowing: BBC News (2000); Calimoso (2000); Esteban and Fabian (2004); Hicap (2004); Reyes (2004).
nr - no exact record.

Table 10. List of Major Technological Accidents in the Philippines, 1991-2005

vigorously addressed, sea accidents are expected to remain frequent and deadly occurrences in the country.

Discussions

The frequency and impact of environmental disasters discussed in the preceding section is summarized in Table 11 with the corresponding "average" impact measured in terms of deaths, families affected, and total cost of damages for the period starting in 1970 or where data are more complete. These averages are better seen as order-of-magnitude estimates rather than exact figures especially for the relatively infrequent phenomena (*i.e.*, volcanic eruptions, earthquakes, and tsunamis) whose impact can be skewed by one or two "extreme" events. Moreover, missing data in some impact categories for a few hazards also underestimate the calculated averages. Despite these caveats, Table 11 along with the individual tables for each hazard type (Table 1-10) allows us to delineate some general rankings and broad temporal trends in the disaster frequency and impact.

General Trends in Disaster Frequency and Impact

Environmental Hazard	Period	Number of Events[a]	Deaths	Families[b] (thousand)	Total Damages (P Million)[c]	Average per Event		
						Deaths	Families	Damage (Million)
1. Tropical Cyclones (TY)	1970-2005	546[1]	20,130	19,148.75	149,904	37	35,071	274.00
2. Floods (FL)	1980-2005	524	1,550	4,479.71	13,175	3	8,549	25.14
3. Landslides (LS)	1980-2005	199	883	15.06	227	4	76	1.14
4. Volcanic Eruptions (VE)	1965-2005	9	572[2]	472.41	13,004	64	52,490	1,444.89
5. Earthquakes (EQ)	1970-2005	12	3,397[3]	284.47[3]	15,791[3]	283	23,706	1,315.92
6. Tsunamis (TS)	1965-2005	4	3,817	53.88[4]	1,940	955	13,471	485.00
7. Droughts (DR)	1970-2005	10	0	2,145.36	24,232	0	214,536	2,423.20
8. Pest Infestations (PS)	1991-2005	176	4	>5.11	2,045	0	>32	11.62
9. Health Epidemics (HE)	1992-2005	54	952	>8.38	>8.62[5]	18	155	>0.16
10. Technological Accidents (TA)	1991-2005	2,754	6,534	3,644.64	22,037	2	1,323	8.00

[a] refer to 'destructive' events where damage (fatalities, houses destroyed, families affected, total cost) estimates exist.

[b] Total number of families affected.

[c] Nominal Peso

[1] Tropical cyclone occurrence within the Philippine Area of Responsibility.

[2] Direct fatalities from eruptions and lahars only; excludes fatalities from 1965 Taal tsunami and lone disease-related death in 2001 Mayon event.

[3] Numbers exclude fatalities and damages associated with tsunamis in 1976 Moro Gulf and 1994 Mindoro earthquakes

[4] Calculated from 65% of total number of families affected by 1976 Moro Gulf and 1994 Mindoro quakes, 20 houses destroyed by 1992 Surigao tsunami, and ~40 people estimated to have died from 1965 Taal Lake tsunami.

[5] Represents financial assitance given to victims, rather than true cost of damages which is likely to be higher.

Table 11. Summary of Frequency and Impact of Environmental Disasters by Hazard Type

Disasters wrought by tropical cyclones are amongst the most frequent but are moderately severe compared to other disaster types, with average losses pegged at P274 million/event (Table 11). Damages exceeding more than P3 billion per tropical cyclone started in 1984 and became more frequent by the 1990s (Table 1). Given that the average number of tropical cyclones within the PAR has remained more or less fixed at 18-20 from the 1950s to the present and that average number of typhoons per year has, in fact, declined slightly from 14-11 in the 1950s-60s to 9-10 (from the 1970s onwards) (PAGASA, 1993; 2004), the increasing losses from tropical cyclone hazards cannot be simplistically and wholly ascribed to "climate change". While acknowledging that tropical cyclone frequency in the western North Pacific basin has not changed over the past 30 years, Emanuel (2005) claims that their destructiveness based on dissipation intensity has increased, a finding challenged by other workers (Landsea, 2005; Pielke, 2005). Thus, it is more probable that the increasing damages from typhoon disasters in the country reflect Filipinos' enhanced susceptibility as a result of population and land-use changes rather than increased hazard probability.

Disastrous floods, next to technological accidents, are the most prevalent calamities in the country, just slightly ahead of tropical cyclones. In terms of severity, however, 'average' flood impact per event measured in deaths (3), families affected (8,500), and monetary damages (P25 million) are an order-of-magnitude lower than those of typhoons (Table 11). The average number of disastrous floods in the country per year, calculated from OCD/NDCC records, has shown a marked increase over time, from 6 in the 1980s, to 26 in the 1990s, and to 36 in the first half of the new century. This increased incidence is paralleled by similar trends in monetary losses. From P466 million in the 1980s, the average total annual damages from floods jumped to P660 million the following decade, and to P944 million during the first half of the millennium. Even allowing for inflation, these costs highlight Filipinos' increased vulnerability to flooding over time.

As a disaster class, landslides occur with much less frequency and produce lower damages than both typhoons and floods (Table 11). In fact, the average cost of damages per landslide (P1.14 million) is the lowest among all geophysical hazards. Moreover, the geographic impact of landslides (Table 3) is evidently more restricted when compared to those of typhoons and floods (Tables 1-2). When seen over the past two and a half decades, disastrous landslides show only very modest increases in terms of average number (4 to 10 per year) and total damages (P5.9 million to P 10. 4 million per year) from the 1980s to the present.

In contrast to the relatively regular occurrence of typhoons, floods and landslides, volcanic eruptions are infrequent and second only to tsunamis in rarity as calamitous events. The severity of Philippine volcanic disasters is skewed by the effects of the 1991 Pinatubo eruptions, whose VEI 6 rating make it at least 2 orders of magnitude greater than all previous and succeeding recorded eruptions (Table 4). Despite this, the decline in the number of fatalities over the past century given comparable eruption VEIs suggests the increasing competence of government scientists to monitor and predict volcanic eruptions. But the collective impact of the more recent eruptions still put this relatively infrequent phenomenon as amongst the most dangerous hazard in the country – averaging 64 deaths, 50,000 families affected, and P1.4 billion in lost properties per event (Table 11).

Just slightly more frequent and destructive than volcanic eruptions are strong ($M \geq 6.2$) earthquakes, whose associated average loss per event (P 1.8 billion) puts it second only to droughts in terms of severity (Table 11). And unlike climate-related calamities such as typhoons, floods, droughts, and geophysical hazards like volcanic eruptions and landslides, the temporal and spatial trends in earthquake impacts show no definite pattern. This underscores the still essentially "random" nature of earthquakes, which makes their mitigation more complicated compared to similar geophysical hazards such as volcanoes and landslides.

The rarity of tsunamis over the period studied is the safest conclusion that one can derive from Tables 6 and 11. Despite this, the average number of lives lost calculated for one tsunami event – 955 – is the highest among all hazard type in the Philippines. Admittedly, this number is an artifact of the over 3,000 deaths associated with the 1976 Moro Gulf tsunami. But viewed as an order-of-magnitude estimate in the light of the December 2004 Sumatran tsunami, this estimate looks very reasonable indeed.

Until recently, droughts as environmental disasters in the Philippines have been under-appreciated for their destructive impact. Their slow-onset character and the absence of fatalities make for less drama than earthquakes or tsunamis but the numbers in Table 11 affirm the growing realization that droughts wreck greater societal havoc than other hazards. In terms of average number of families affected (214,000) and the monetary cost of damages (P2.4 Billion) per event, droughts in the country can truly qualify as environmental catastrophes. In addition, the decreasing recurrence intervals of ENSO's warm episodes coupled with the increasing associated damages over the past 35 years make it very likely that droughts will increasingly capture public attention as object of disaster mitigation and response.

Starting in 1996, crop production and total damages from pest infestations began to noticeably increase relative to previous years (Table 11). Damages from pest hazard were most severe in 1998 in terms of number of outbreaks, areas affected, and value lost. Whether this phenomenon was related to the strong ENSO-event of that period remains to be confirmed. Nevertheless, because they largely strike rural farming communities, pest infestations have a stronger social bias as far as population impact than other environmental threats except health epidemics.

Incompleteness of data for health epidemics and the heterogeneity of events included in "technological accidents" make any definitive conclusions on their temporal trends problematic. This caveat, notwithstanding, the number of outbreaks, fatalities and families affected by health epidemics have not shown any apparent increases (or decreases) over time. And except for the occurrence of SARS in 2003, the same set of infectious diseases is responsible for much of the country's health disasters over the last decade or so.

Public policy implications

For informing risk management policy and practices, the statistical data in Table 11 are plotted in Figure 9 in terms of frequency (number of occurrence/year) and the severity (total Peso damages/event) of disasters for each hazard type. Diagonal lines connecting equivalent values along the frequency and severity axes denote zones of *relative* equivalent relative risk. Several trends are worth noting. Technological accidents constitute a discrete high frequency but moderate severity domain. Geophysical hazards such as tsunamis, volcanic eruptions, and earthquakes join droughts as a distinctively low frequency but high-severity cluster. Floods, typhoons and pest infestations form a separate class of moderate frequency and moderate severity disasters. Landslides are unique among geophysical hazards because they are generally low-severity but moderately frequent disasters, characteristics it share more with health epidemics than other types of geological disturbances. Of the 10 environmental types of disasters considered, the country clearly is at "very high" risk for seven – typhoons, technological accidents, floods, volcanoes, earthquakes, droughts, and pest infestations. Tsunamis, and landslides

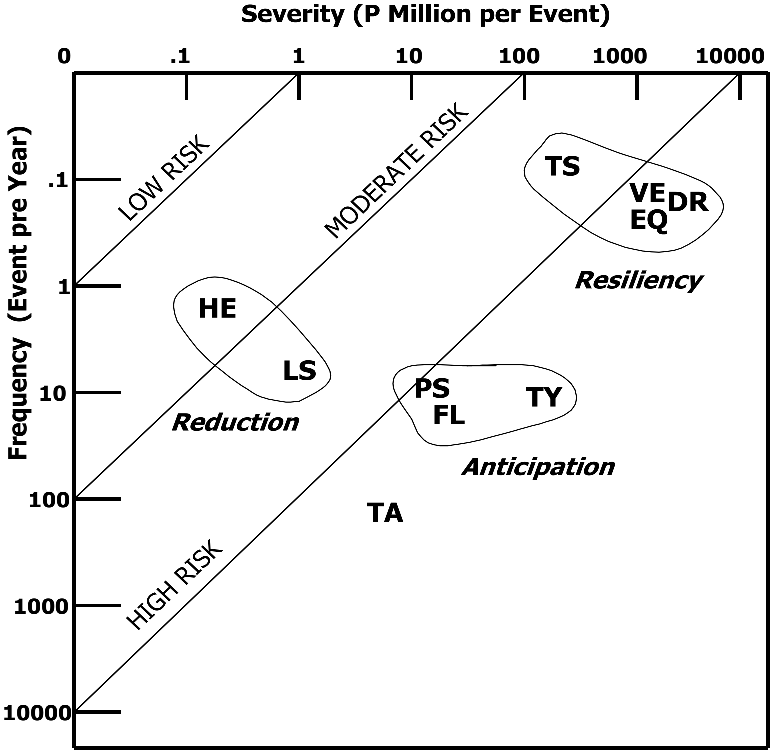


Fig. 9. Hazard Frequency and Severity in the Philippines, ~1970-2005

constitute a "high-risk" threat for the country while health epidemics can be regarded as a "moderate risk". Thus, the risk zoning of environmental threats is not dependent on whether they lie on the ecological or anthropogenic ends of the spectrum. Figure 9 provides an alternative framework for designing generic government and civil society responses by noting that disaster clustering shapes the *nature* of mitigation approaches to be employed while the risk zoning governs the *priority* to be afforded for such responses. This applies to all hazards except for the "technological accidents" whose highly heterogeneous composition (airplane crashes, civil strife, fires, etc.) requires a more meticulous distinction beyond the scope of this study. The low-frequency high-severity disasters merit a *resiliency* approach (Wildavsky, 1988) that entails making short-term sacrifices in order to avoid or withstand huge losses in the future. The emphasis of a *resiliency* strategy is not the mobilization of resources before a hard-to-predict catastrophic event but rather the need to enhance long-term capacities that may require forgoing many small but short-term benefits. Requiring seismic safety standards and other building restrictions, for example, imposes additional costs on property owners but may significantly decrease fatalities in the event of a major tremor. Similarly, a permanent ban on farming and habitation on slopes of active volcanoes deprive poor farmers of rich soil but helps minimize vulnerability to volcanic eruptions. Water conservation measures and repairs of leaks in water delivery lines inconvenience many people but can be rewarding when a drought strikes. While these and similar practices illustrate specific resiliency tools, a generic resiliency approach is to increase community wealth and knowledge because wealthier and more informed societies have greater flexibility in meeting disasters (Wildavsky, 1988). Of course, such approach may be said to apply for all hazards, regardless of their frequency and severity.

In contrast, an *anticipation* strategy is more appropriate when the hazard is fairly predictable in terms of timing and location (Fig. 9). This applies to typhoons (season and paths are generally well established), floods (high-risk areas during rainy season known from previous experiences), and pest infestations (often coinciding with cropping seasons in agricultural districts). The essence of an *anticipatory* strategy is to stockpile and mobilize resources for monitoring and responding to the projected events (Wildavsky, 1988). For example, good anticipation requires deploying more scientific personnel and meteorological equipment to monitor typhoon paths and brewing floods during rainy seasons. Similarly, agriculturists can help farmers monitor and prevent incipient pest infestations through combined instructional briefings and independent verifications. This does not mean that monitoring is not an integral component for resiliency-type disasters such as volcanic eruptions and tsunamis. The main difference is that the predictability of some types of disasters provides decision makers with stronger political basis in acquiring and deploying additional resources. At another level, *anticipation* requires stockpiling of goods and critical equipment that are sure to be needed when the expected hazard turns into disaster – canned goods, bottled water, blankets, medicines, etc. Of course, stored supplies and critical equipment can be used to respond to all classes of environmental disasters; but it makes more sense to store supplies in anticipation of typhoons than for tsunamis. *Anticipation* also does not mean that striving for *resiliency* against floods, typhoons, and pests should not be attempted. But the resiliency often required for these more frequent events are of a different order, more reliant to a greater degree on individual households' and local communities' initiative than those for earthquakes, droughts, etc. where a more top-down and comprehensive strategy is clearly in order.

A *prevention* strategy to mitigate health epidemics and landslides (Fig. 9) aims to significantly reduce the number of occurrences themselves, and thus is distinct from both *resiliency* and *anticipation* approaches that basically address populations' adaptive capabilities. *Prevention* is premised on the fact that the proximate factors for both landslides (unstable slopes) and health epidemics (diseases) can be addressed through a menu of widely known and readily available measures. For health epidemics, for example, short-term options can include vaccinations, insect spraying, quarantine, etc; long-term measures include hygiene education, availability of clean water and waste disposal facilities to all communities, strengthening medical emergency preparedness, etc. Immediate measures that can significantly minimize destructive landslides include slope rip rapping, water drainage or canal construction, and infrastructure ban on high-risk zones; long-term mitigating approaches can involve massive reforestation, strict land-use regulation, and ground movement or subsidence monitoring, among others. In other words, these steps substantially reduce the probability of landslides and health outbreaks themselves that are difficult, if not impossible, to do for say typhoons, earthquakes and tsunamis.

Concluding remarks

This study's compilation of unpublished disaster statistics for ten classes of environmental hazards, possibly the single most comprehensive presentation of official Philippine government records, has provided a more systematic basis for comparing the frequency and severity of environmental disasters in the country over the past 20-30 years. Technological accidents, floods, tropical cyclones are the three most frequent disasters while tsunamis, volcanic eruptions, and droughts occur the least. In terms of peso value, droughts, earthquakes, and volcanic eruptions are the most destructive while pest outbreaks, landslides and health epidemics inflict the least monetary damages. Moreover, the costs of destructive floods, typhoons, and droughts appear to be generally increasing over time, highlighting Filipinos' increased vulnerability to these environmental threats.

The framework relating disaster severity and frequency in classifying the relative risks and generic mitigation responses for the 10 environmental hazards represents both a summary of what is currently known and a blue print for further investigations. Important gaps in information remain, especially on health epidemics and, to a lesser extent, tsunamis. There is also a need to explore how unofficial disaster tallies from NGOs and the media can be reconciled with government records that some critics contend either understate fatalities or overstate financial damages. Undoubtedly, some of the figures in this study may be modified when more data are unearthed. Nevertheless, the systematic quantification and the risk framework presented by this work has potentially great application in such diverse areas as insurance design, government budgeting, and natural and social science research of specific disaster events.

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