CHAPTER 2

OVERVIEW OF PAST AND RECENT DISASTERS IN THE PHILIPPINES

2.1 Introduction

The Philippine Archipelago is a cluster of 7,107 islands with an area of 0.3 million square kilometers and a coastline over 17,000 km long (Fig. 2.1). Located along the western rim the Pacific Ocean, the country has a population of about 60 million with a annual growth rate of 2.3%. The two major islands of the archipelago, Luzon and Mindanao, cover 65% of the total land area, while Luzon alone has a surface of about 120,000 square kilometers, most of which is mountainous.

The Philippine Archipelago has a humid tropical climate with an average temperature range of 24-35 degrees C and midday summer peaks over 38 degrees C. Humidity is usually high and rainfall ranges from 2,000 to 4,000 mm/year depending on the region. On western Luzon 80% of the total annual rainfall occurs from July through September, while the same percentage affects eastern Luzon from February through May A three-storied type rainforest originally covered the lowlands of the archipelago, the dominant trees mainly belonging to the Dipterocarp family. Deforestation be-

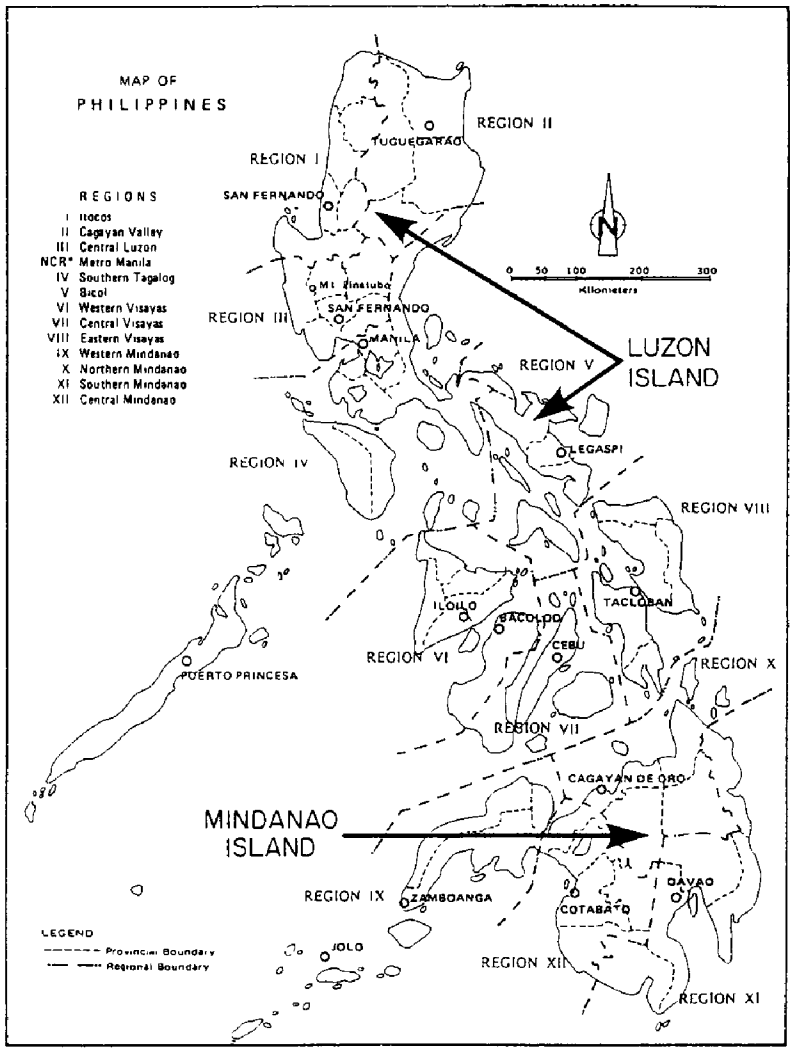

Fig. 2.1 – *The Philippine Archipelago (ADB, 1991b).*

came extensive after the Second World War, and little of the lowland is still forested at present. By the end of this century only the original vegetation of higher-altitude zones may have survived.

The tectonic setting and climate make the Philippines highly vulnerable to different types of hazards. The convergence of the Eurasian and Pacific Plates and the monsoon climate are mainly responsible for the frequent disasters which hit the archipelago.

Numerous calamities of varying nature were documented by Spanish chroniclers since the middle of the 17th century. Earthquakes, volcanic eruptions, landslides, mudflows, tsunamis, typhoons and floods still plague the country, as they did in the past.

Although natural disasters occur in many parts of the world, the Philippine Archipelago is a major target for quite a range of them (Chapter 1, Fig. 1.1).

2.2 The framework of geological disasters in the Philippines

2.2.1 General

A fundamental recognition in natural sciences is that the earth is a dynamically evolving body. The outer layer of the planet, the lithosphere (about 100 km thick), has been continuously subjected to structural and morphological changes throughout geological times. The physical activity of the earth's crust is partly the result of the energy supplied as heat from the earth's interior, partly as energy provided by the sun in the form of radiation. The combined effects of the related forces resulted in a sequence of evolutionary processes which have shaped the lithosphere for hundreds of millions of years.

The phenomena resulting from the aforementioned sources of energy are known as the geologic cycle. The concept, which was introduced by James Hutton in 1785, includes two major components, or subcycles (Fig. 2.2):

– the hydrologic cycle, which is the cyclical path of water from the oceans into the atmosphere and then back to the oceans through precipitation and flowing along rivers and streams. This complex path is responsible for the dismantling of high ground and the downward transportation of sediments towards flat-land areas and marine floors. In connection with the incoming solar energy, the cycle drives the chemical reactions and physical processes which are essential to the alteration and degradation of superficial rocks and to the development and evolution of biological processes.

– the tectonic cycle, which consists of processes related to the heat stored in the earth's interior; these include the continuous deformation of the crust, the motion of the lithospheric plates, the upheaval of mountain ranges, the rise of basaltic magma along oceanic fractures, the intrusion of molten rock into volcanic chambers and the consumption of the oceanic crust through subduction. The motion of continental and oceanic slabs, better known as plate tectonics is responsible for

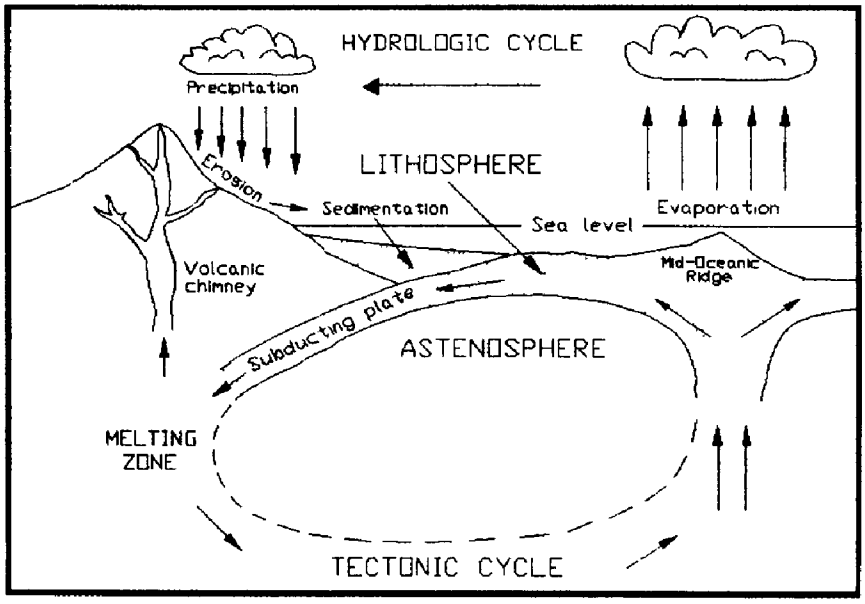

Fig. 2.2 – *The geologic cycle and the hydrologic and tectonic subcycles.*

the collision and breaking apart or separation of plates. Numerous earthquakes and volcanic eruptions associated with the motion of plates occur along the boundary zones between them.

The geologic cycle is characterized, at the local level, by prolonged periods of calm and routine processes, suddenly interrupted by episodes of highly dynamic activity. The troposphere (the interface where life and human development are concentrated) represents the physical space where tectonic and hydrologic sub-cycles widely exert their hazardous influence.

The disasters which occurred in the Philippines during 1990 through 1991 are due to the descent of eastern and western sea floors beneath the Archipelago and the ensuing motion of crustal blocks along the numerous faults in the area. High seismicity and volcanism are associated with these dynamic processes: the numerous and strong earthquakes which have been hitting the Philippines, since remote geological times, mainly originate near and along plate boundaries, subduction zones and the Philippine Fault, while eruptions occur along active volcanic lineaments. The seismicity of the Archipelago is also responsible for a number of tsunamis along the coastal areas, landslides in mountainous provinces and liquefaction in the plains. The latter phenomenon, in turn, can produce earthflows, lateral spreading and the loss of bearing capacity of soils underneath the foundation of buildings and other structures.

2.2.2 Earthquakes and tsunamis

Earthquakes occur throughout almost all the Archipelago. Figure 2.3 shows the location of epicenters during the last decades.

According to PHIVOLCS the Country is hit by an average of 5 earthquakes per day. Table 2.1 shows Intensity, Magnitude and number of casualties of the most destructive events during the last four decades (Earthquake and Tsunami, 1990).

Giant sea waves called tsunami (from the Japanese), mainly produced by submarine earthquakes, volcanic eruptions and huge submarine landslides, also occur along the coast of the Philippines, but are less frequent than earthquakes.

Twenty-seven known tsunamis affected the Philippine coasts from 1603 to 1975. On 16 August 1976 a tsunami, induced by the Moro Gulf earthquake, devastated the southwestern coast of Mindanao. The 5-meter high waves killed 3,000 persons, injured 8,000 and left about 12,000 families homeless (Earthquake and Tsunami, 1990).

Figure 2.4 shows tsunami-prone areas in the Philippines and their relationship with the tectonic setting of the Archipelago.

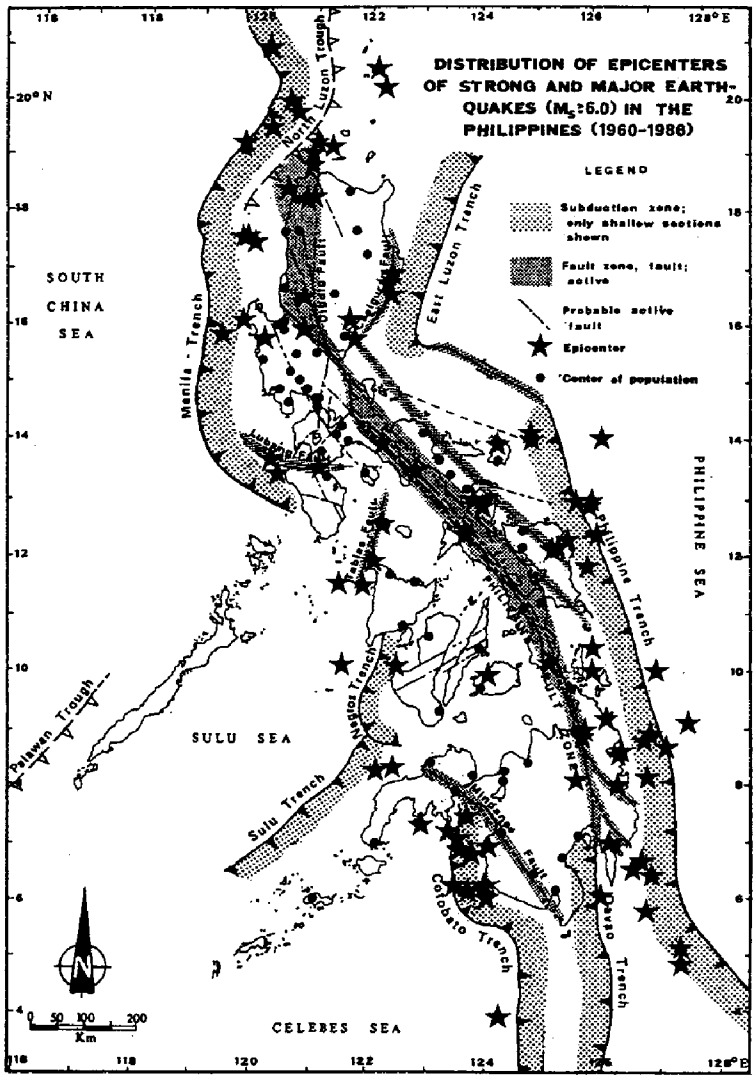

Fig. 2.3 – *Distribution of earthquake epicenters (1960-1986) within the Philippine Island Arc after Punongbayan (PHIVOLCS, 1987).*

2.2.3 *Volcanic eruptions*

The Philippines being located along the Pacific Ring of Fire suffer a remarkable amount of volcanic activity. Forty-one destructive eruptions occurred in the Archipelago during the period 1572-1991, an average of one major event about every 10 years. Intermittent minor eruptions, however, accompanied by smoke, tremors and heat are quite frequent in active volcanic districts. Table 2.2 gives details of major eruptions of the most dangerous volcanoes in the Philippines.

Volcanic eruptions are concentrated along some major tectonic lineaments. Out of 220 volcanoes, 21 are classified as active (Punongbayan, 1987), most of the others are considered to be inactive at present, while the remaining are dormant (Fig. 2.5).

An example of recurring volcanism in a highly populated area of the Philippines is the activity of Mt. Taal, 60 km south of Manila. According to Hargrove (1991) in 1754 a several month-long period of violent phreatomagmatic activity ended by partially modifying the volcano's shape, by closing up the wide channel connecting the caldera to the sea and changing it from a saltwater lagoon into a freshwater lake. The next violent event occurred in 1911 with an electrical display visible from a distance of hundreds of kilometers. Huge columns of smoke, mud, fine ejecta, earthquakes and widespread destruction were associated with the eruption. Metro Manila is built on volcanic ejecta and is crossed by an active tectonic lineament, the Marikina Fault. The most recent eruption in the Philippines was that of Mt. Mayon (Legaspi, southern Luzon), which resumed its activity on February 3, 1993. Recent previous eruptions occurred in 1984 and 1977.

2.2.4 *Landslides and liquefaction*

The widespread slope instability of the philippine mountains is mainly due to the interaction of geologic factors and seasonal rains. The landforms of the Archipelago are commonly affected by an accelerated evolution because of the continuous upheaval of the region, the related steepening of

TABLE 2.1 - Destructive earthquakes in the Philippines from 1954 to 1990

Date	Epicenter	Intensity	Magnitude	Dead	Injured
July 16, 1990	Rizal (Nueva Ecija)	VII	7.7	1,666	3,561
Aug. 17, 1976	Moro Gulf (Mindanao)	VII	7.9	3,739	8,000
Apr. 7, 1970	Baler (Quezon)	VII	7.3	15	200
Aug. 2, 1968	Casiguran (Aurora)	VII	7.3	270	600
Apr. 1, 1955	Lanao (Mindanao)	VII	7.5	291	713
July 2, 1954	Bacon (Sorsogon)	VII	8.3	13	101

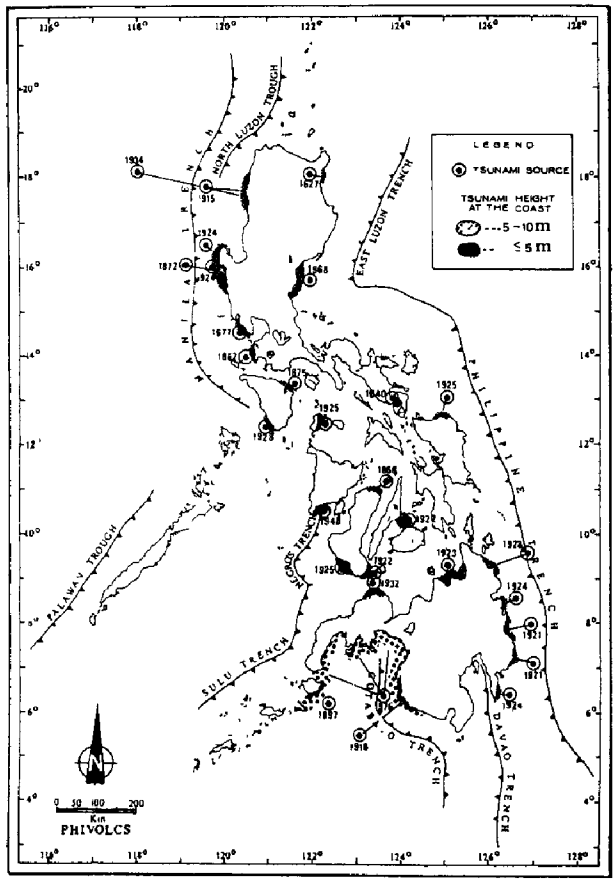

Fig 2.4 – *Tsunami prone areas of the Philippines after Uy and Punsalan (PHIVOLCS, 1987).*

slopes, the rejuvenation of river valleys and the strong erosion induced by the high-intensity tropical rains. Earthquakes and volcanic eruptions in general powerfully contribute to shape the morphology. The former generate landslides through the shaking of slope materials, the latter by depositing huge quantities of pyroclastic products with the potential for sliding. The landscape of the Archipelago, moreover, is no longer protected and stabilized by the natural forest vegetation, which has been largely removed by the exploitation of forest resources and wildfires.

A variety of types of landslides are usually triggered by strong quakes in the mountainous and hilly provinces of the Philippines. Seasonal landslides, which are rather common in the Country, have exerted yearly recurring impacts on the landscape frequently damaging roads and other infrastructure during this century. The importance of mass movements in Luzon and the related damage were clear after the July 1990 earthquake, the 1991 eruption of Pinatubo and the monsoon rains which started soon after these events.

Mudflows (also termed lahars in Indonesia) are huge downward movements of pyroclastic material which accumulates on the slopes of volcanoes during eruptions. Heavy rains by causing downhill movement of finer ejecta trigger the initiation of mudflows. Once the lahar is in motion under the effect of prolonged rains it can receive and carry coarser sediments, blocks and boulders. When the fluid mass reaches the flat land it usually has devastating effects on infrastructure, agriculture and the environment. Sand layers from lahars related to past eruptions were discovered in various places on the Central Plain.

During earthquakes, water-saturated sand deposits can liquefy under the effect of ground shaking. This means that the soil becomes fluid with dangerous consequences for houses and other structures. When liquefaction occurs, foundations can sink, tilt or undergo differential settlement.

Based on Spanish chroniclers reports the area around Dagupan City (Lingayen Gulf) in the Central Plain is thought to have undergone liquefaction at least twice in historical times. Liquefaction occurred during the 1792 and 1896 quakes, as well as during the July 16, 1990 event. Before the July 1990 tremor, liquefaction had been triggered in Panay Island (Central Philippines) during the May 1990 quake which caused considerable damage (Observer, PHIVOLCS, 1990). Fossilized traces of sand liquefaction in various parts of the Philippines were recently discovered, indicating that this phenomenon is quite common throughout the Archipelago (IMAI et al., 1991).

2.3 Climate-related disasters

The vulnerability of the Philippines to climate-related disasters is mainly due to the many powerful typhoons yearly crossing the southwest Pacific Region. The high speed winds and abundant rain-

TABLE 2.2 - Major volcanic eruptions in the Philippines during the period 1572 - 1993 (adapted from ADB, 1991a)

Names of Volcanoes	Eruptions
Pinatubo (Zambales)	2 eruptions the most recent in June 1991, previous one about 400 years before
Mayon (Legaspi)	44 significant eruptions since 1616. Worst eruption was in 1814 (over 1,200 casualties). The most recent eruptions occurred in 1993, 1984 and 1977
Taal (Manila)	33 eruptions since 1572. The largest occurred in 1754 and 1911 (1,300 casualties)
Bulusan (Sorsogon)	First eruption in 1852, followed by intermittent eruptions, most recent in 1985.
Canlaon (Negros)	21 eruptions, first in 1866 and last in 1985
Hibok-hibok (Northern Mindanao)	Activity recorded between 1948 and 1953 with most destructive phase in December 1951 when an avalanche killed more than 3,000 persons

TABLE 2.3 - Number of typhoons, 1948-1990

Year	Typhoons
1948-1986	189
1987	6
1988	4
1989	7
1990	8

falls, which recurrently hit the area, bear an enormous destructive potential. The devastation is magnified by the fact that human activities are often concentrated in flat, flood-prone areas.

The Philippines are located in the typhoon-prone area of the Pacific and crossed by 20 to 30 typhoons per year mainly in the period from June to November. The most abundant monsoon rainfall is usually concentrated in July, August and September. The number of destructive typhoons during the period 1948-1990 is given in Table 2.3.

Figure 2.6 shows typhoon tracks across the Philippines during the period 1955-1985. Ninety-five percent of the typhoons crossing the Philippines originate in the Pacific Ocean, while the remaining 5% come from the South China Sea. The eastern coast of the Archipelago is, thus, the most vulnerable, Northern Luzon having the highest frequency of typhoons during the year. Table 2.4 shows wind speed, number of casualties, wounded and dispersed people during 1986-91 typhoons. The destruction of houses, port facilities, drainage systems, agricultural land and infrastructure should be added to these figures.

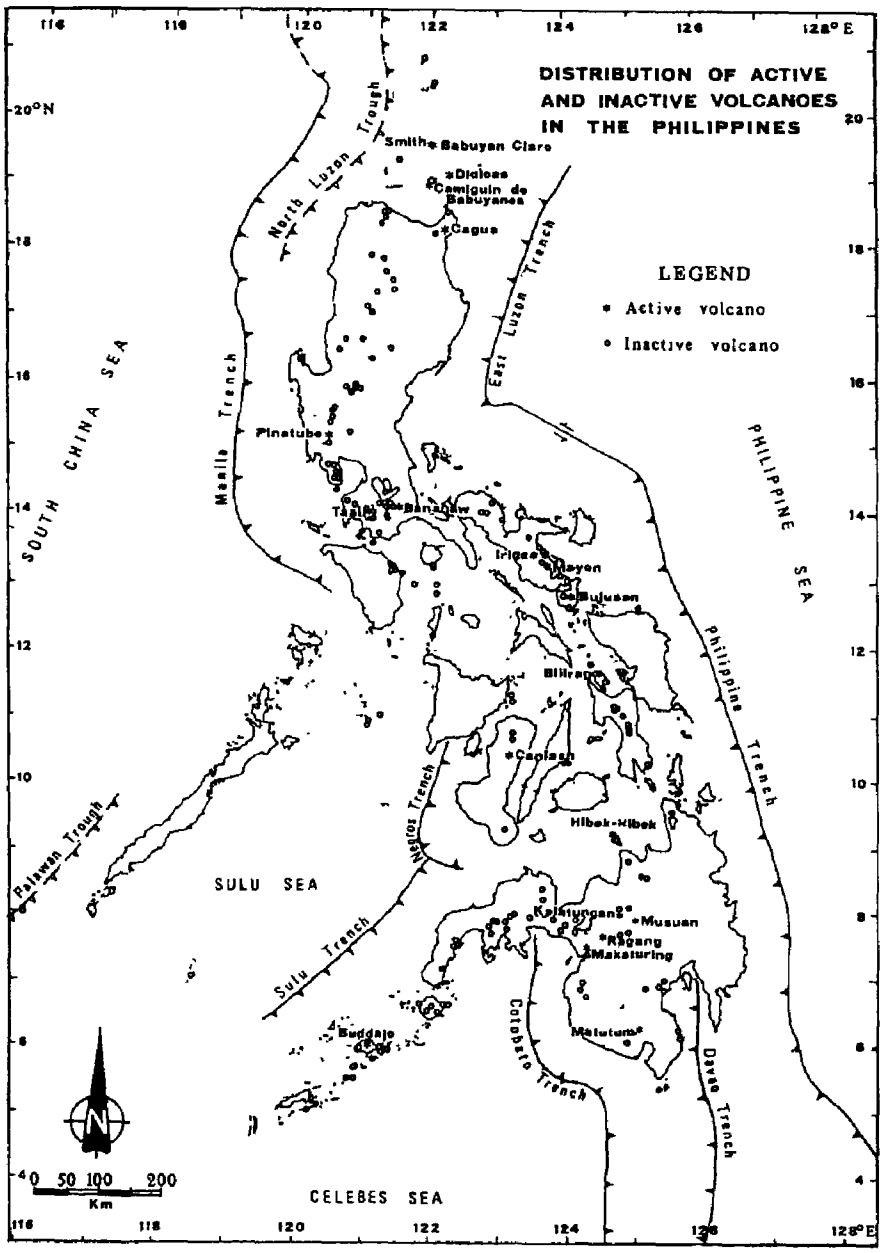

Fig. 2.5 – *Distribution of volcanoes in the Philippines after Punongbayan (PHIVOLCS, 1987).*

The exponential trend of the human losses shown in Table 2.4 may be partly due to a more reliable assessment of damage within the affected areas, partly to the inflation of losses and damage at the local level to attract government funds.

According to PAGASA, 47% of the annual average rainfall is related to typhoons. The low-lying lands, which represent about 40% of the total land surface of the Philippines, are particularly vulnerable to flooding. In July 1972, during a record rainfall, low-lying areas in Pampanga and Bulacan provinces (northwest and north of Manila, respectively) were submerged by over 2 m of water. Severe province-wide flooding occurred in 1974, 1978, 1981 and 1986. Almost every year, parts of Manila and the surrounding flat land are flooded. The highest rainfall concentration occurs when slow-moving or almost stationary typhoons follow one another, thus extending the period of heavy rainfall. In urban areas, the lack of maintenance of drainage facilities increases vulnerability to flooding. The primary effects of typhoons such as the destruction of houses, infrastructure and services are often followed by devastating secondary damage due to flooding and landslides.

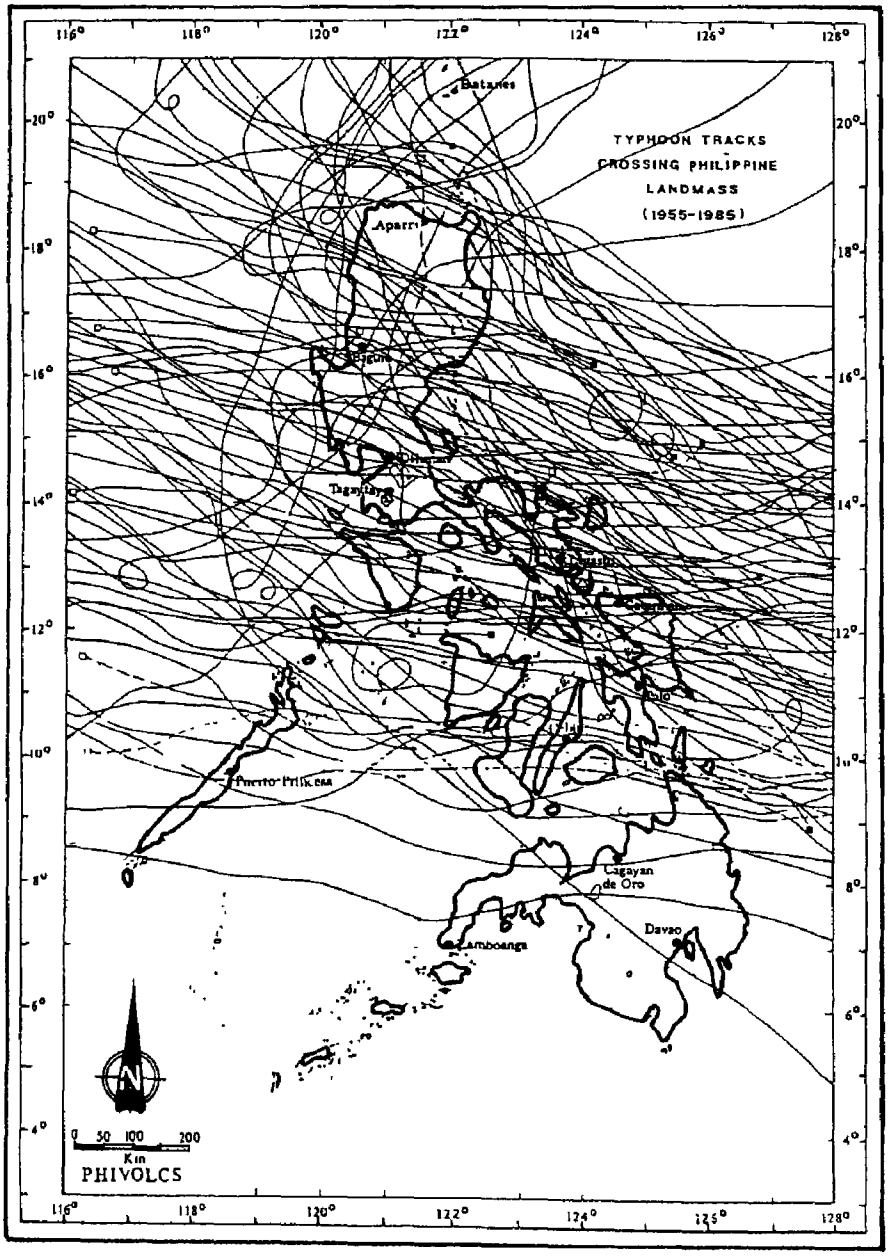

Fig. 2.6 – *Typhoon tracks over the Philippines, 1955-1985, (Nufable, 1986) after Punongbayan (PHIVOLCS, 1987).*

TABLE 2.4 - Data on typhoons in the Philippines, 1986 - 1991					
Typhoon Name	Date	Maximum Wind speed in km/h	Dead	Injured	Missing
Thelma	Nov. 1991	200	5000	2500	
Ruping	Nov. 1990	205	508	1274	240
Unsang	Oct. 1988	215	157	316	60
Sisang	Nov. 1987	240	979	927	
Pepang	Oct. 1987	220	141	67	
Herming	Aug. 1987	240	94	468	
Gading	Jul. 1986	205	89	16	20

2.4 The 1990-91 geological disasters in Luzon

The recent disasters which struck the Philippines during 1990 and 1991 added up to a regional calamity with loss of lives and unprecedented destruction (Fig. 2.7). The earthquake which hit the island of Luzon on July 16, 1990 had a Magnitude of 7.7 (Richter) and produced a spectacular major ground rupture over a distance of 120 km, plus minor surface faulting.

The unprecedented length of the major rupture, its 6.2 m of maximum horizontal displacement, the regional-scale liquefaction in Central Luzon, and the numerous landslides in the mountainous areas are among the most destructive and best documented geological phenomena of this century. The seismic swarm which soon followed the quake and lasted for a few months was interpreted as a subsurface rearrangement of basement blocks in the area.

The subcrustal reorganization was in turn responsible for triggering the intrusion of molten rock, and the 1991 awakening of Mount Pinatubo and Mount Taal, two volcanoes located north-west and south of Manila, respectively.

The powerful June 1991 eruption of Pinatubo spewed volcanic ash over five Central Luzon provinces, blanketing almost 10,000 square kilometers of landscape, and whitening South China Sea waters; the explosion caused major destruction and fatalities. The primary effects of the earthquake and the eruption produced huge environmental impacts, but the additional devastation of the landscape which followed these events was caused by the heavy monsoon rains of 1990-1994. For months abundant downpours initiated massive slope instability and catastrophic erosional processes.

The interaction between the rains and the soils loosened by the quake on the one hand, and the ash deposited by Pinatubo on the other, produced huge downslope movements that exacerbated the effects of the primary damage. A factor that facilitated the mobilization of sediments was the widespread deforestation in Luzon during the last decades.

Most Filipinos, who have experienced a number of calamities during their lifetime, have traditionally fought adverse natural phenomena. In a famous church in Intramuros (Manila), for example, an inscription states that it was demolished four times by earthquakes, badly damaged by typhoons and finally reconstructed after bombing during the Second World War.

A significant difference exists, however, between the disasters of 1990-1991 and those of the past. Until a few decades ago the Country was sparsely populated and more extensively covered by rainforest, thus, the damage was much smaller. The population mostly lived along the coastline and hazards such as landslides, flooding and lahars had a lesser impact. The 1990-91 disasters took place in a densely populated Country, in which large parts of the mountainous areas had been deforested.

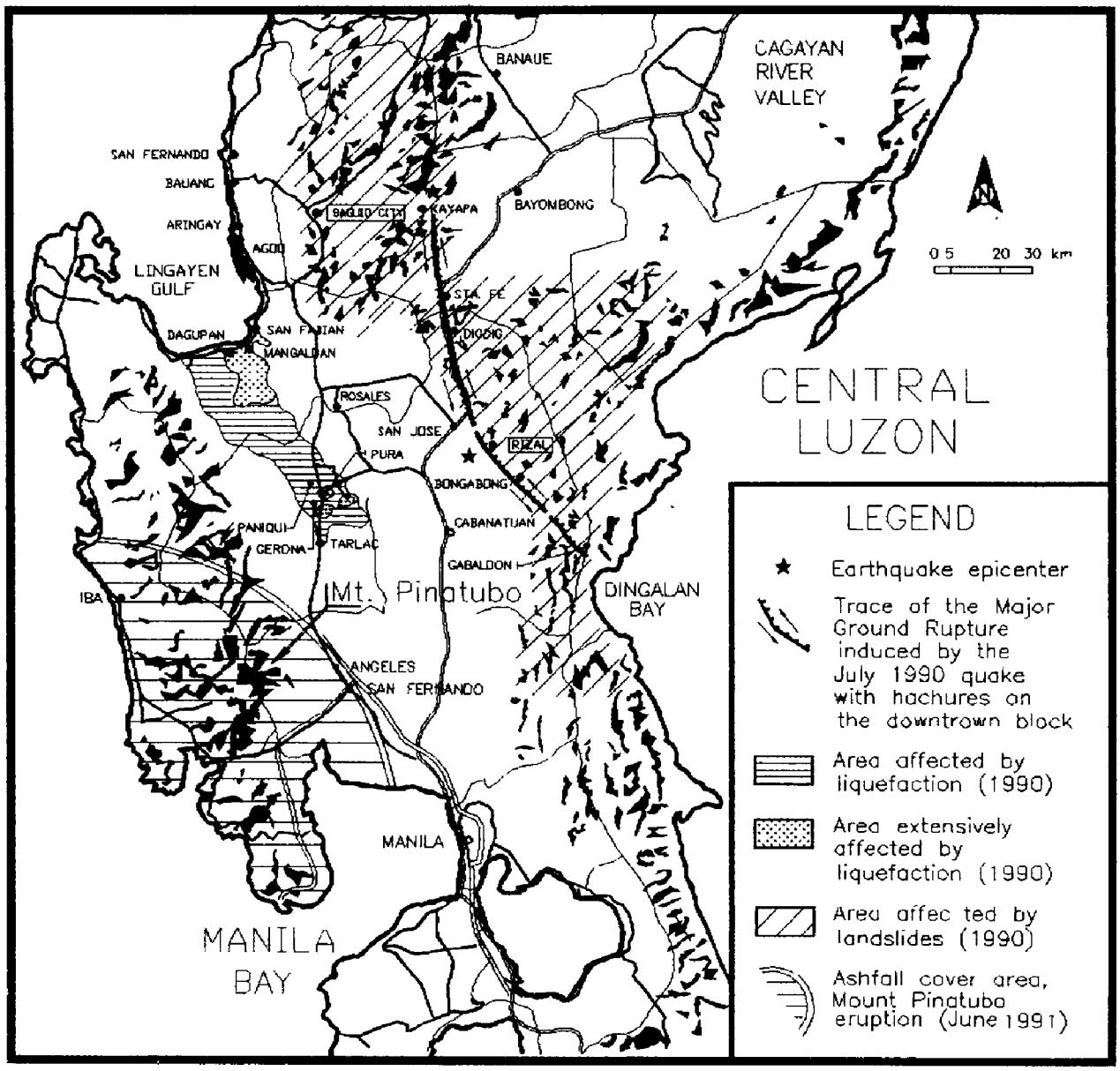

Fig 2.7 – *Overview of the 1990 and 1991 disasters in Luzon (the area affected by ground ruptures, landslides and liquefaction was adapted from Punongbayan and Umbal, 1990). The ash blanket within about 50 km from the crater was deposited during the major explosive episode (June 12-15, 1991). Winds from the storms blew ash to Manila and further south as well as west towards Vietnam and Cambodia*