Lessons Learned from the Recent Natural Disasters in Indonesia

by Sri Prabandiyani R. W

Chapter 4
Lessons Learned from the Recent Natural Disasters in Indonesia

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4.1 Introduction

Indonesia has 245 million people located in the world's largest archipelago on the Ring of Fire who are at risk from earthquakes, tsunamis, volcanoes, and landslides. Earthquakes, tsunamis, and volcanoes occur as a result of ongoing subduction of the Indo-Australian plate in the vicinity of Indonesia. It is one of the seismic sources in this area. High frictional stresses also cause medium earthquakes on the overriding plate that are often observed within and to the south of the island. The megathrust region to the west-northwest of Sumatera and Java has also caused colossal earthquakes, as the region is subject to medium, large, and massive earthquakes. Several major earthquakes recently occurred in Aceh in 2004, Nias in 2005, Yogyakarta, West Java and West Sumatra in 2006, Bengkulu and West Sumatra in 2007, and West Java and West Sumatera in 2009. Some of these were followed by large tsunamis that claimed the lives of hundreds of thousands of people and damaged half a million structures. The social and economic consequences of these earthquakes are tremendous.

Most of the islands in Indonesia form part of an active volcanic mountain chain. Geotectonic activities in the terrain consist of extremely complex morphostructural units within an uplifted sedimentary and frequently active volcanic mountain system. Weathered soils are commonly found in Indonesia as a result of volcanic activity. The soils predominantly consist of clay and sandy mixtures. The weathered soils are layered on the impermeable soil and rock. The geomorphologic features of many slopes in Indonesia are similar in that they consist of folded marls or weathered volcanic deposits overlain by sequences of colluvium derived from volcanic breccia and ash. Massive deposits of these porous breccia and ash materials occur on the steeper sections of slopes to form huge collection areas of groundwater. Indonesia has a climate that provides one of the most active chemical-weathering environments to be found anywhere in the world. However, for tens of thousands of years, volcanic processes and tectonic uplift resulted in accretion rates that kept pace with denudation. Consequently, the terrain and particularly its slopes are in a constant phase of adjustment to the two processes. Periods of peak rainfall occur between January and February and again between March and early May. This corresponds to the times when the majority of landslides and high rainfalls occur.

4.2 Recent Earthquakes

Geologically, Indonesia lies on active tectonic plates. Hence, earthquakes occur daily in the region, and those with a 5-Mw magnitude or larger happen weekly. Figure 4.1 shows the epicenters of recorded earthquakes in Indonesia during 1992–2000 (BMKG, USGS 2009). Earthquakes struck West Java on September 2, 2009 and West Sumatera on September 30, 2009.

4.2.1 Padang Earthquake

A 7.6-Mw earthquake hit Padang on September 30, 2009. The epicenter was about 60 km northwest of Padang, at a depth of more than 120 km. The Mentawai Fault was responsible for this earthquake. This fault is parallel to the Sumatra Fault and situated between the trench and the Sumatera fault (Fig. 4.2) (Shieh 2009). Many aftershocks occurred, and more were expected in the days and months ahead. Most aftershocks are at least two degrees of magnitude smaller that the main shock, such the first reported aftershock, which was 5.5 Mw. The 6.6-Mw earthquake on October 1 appears to not have been an aftershock strictly speaking. It occurred more than 200 km away from the September 30 earthquake rupture on a section of the Sumatran fault. That fault produced many large (7–7.5 Mw) earthquakes between 1892 and 1953, but had been mostly quiet for the past half-century. Figure 4.3 shows the relationship of the September 30, 2009 earthquake to the September 2007 ruptures (Konca et al. 2008). The earthquakes in September 2009 years ago were caused by fault ruptures farther to the south from Padang. The seismic intensity distribution of the earthquake was shown in Fig. 4.4 (BMKG, USGS 2009, USGS). In Padang and Pariaman, the reported earthquakes were greater than VII on the Mercalli scale. At those locations, there was heavy damage to both infrastructures and lives.

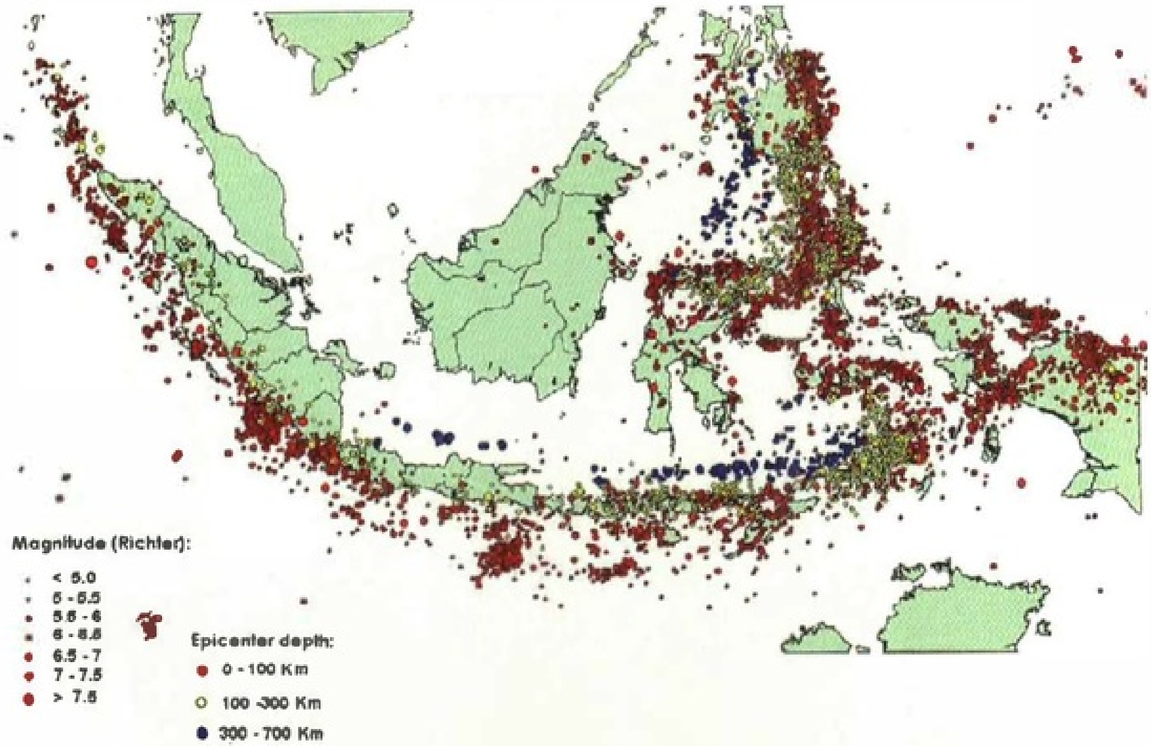


Fig. 4.1 Recorded earthquake in Indonesia during 1992–2000 (BMKG, USGS 2009)

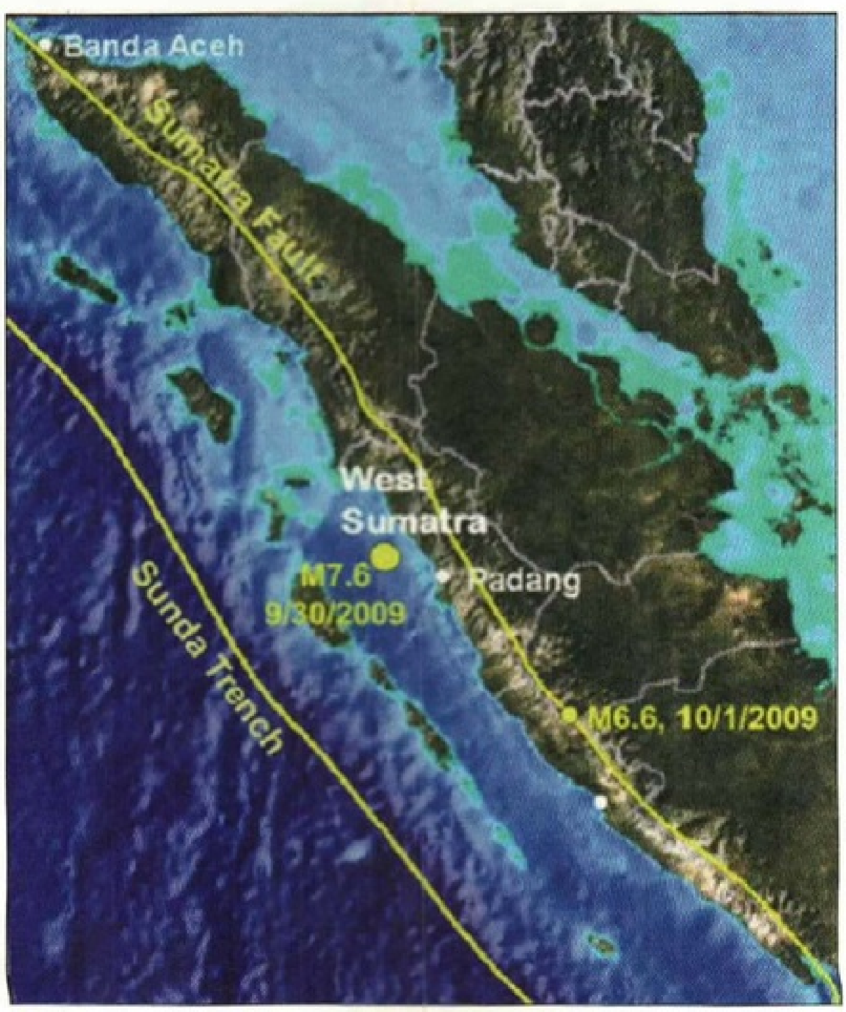


Fig. 4.2 Location of the September 30 and October 1 earthquake epicenters on the Sunda thrust fault and Sumatra strike-slip faults (Shieh 2009)

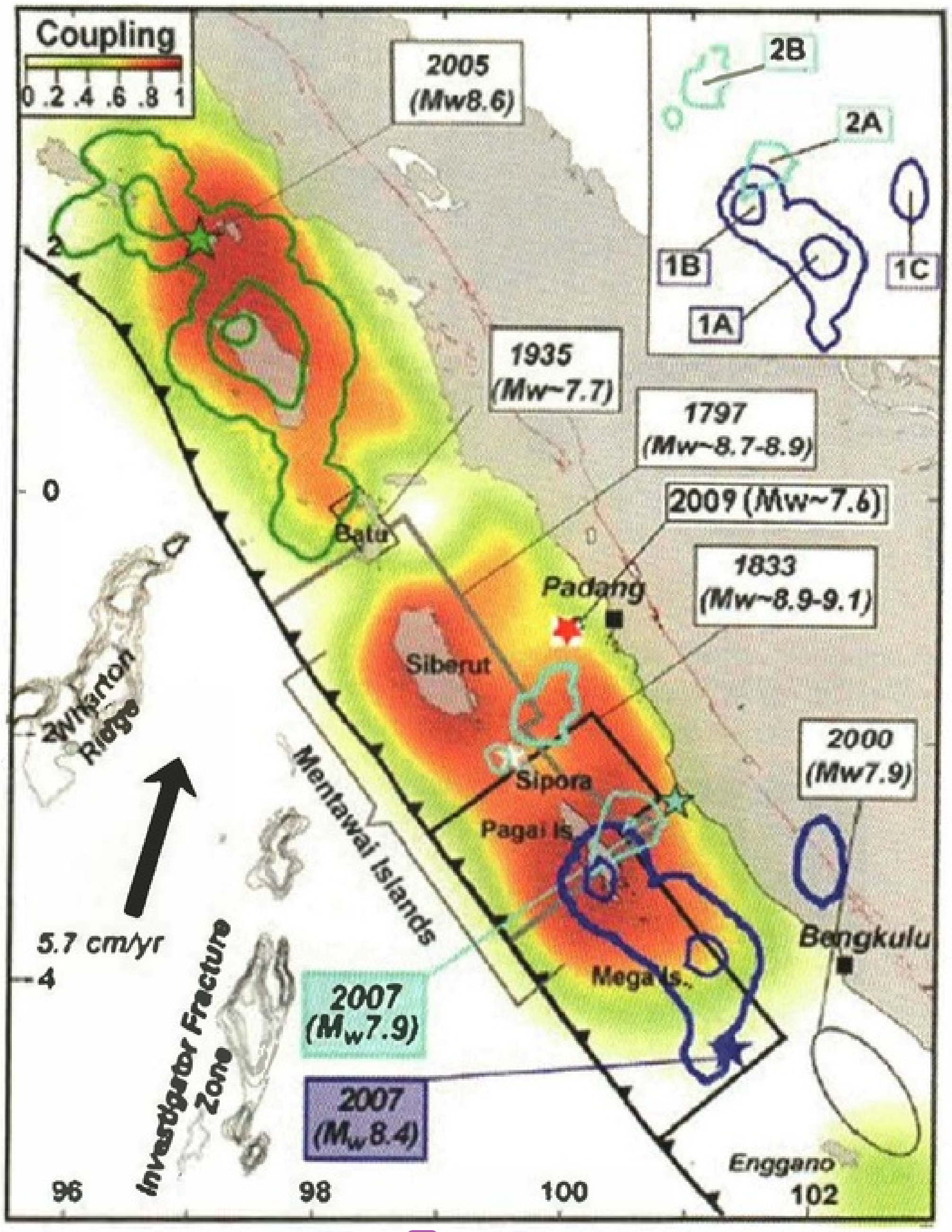
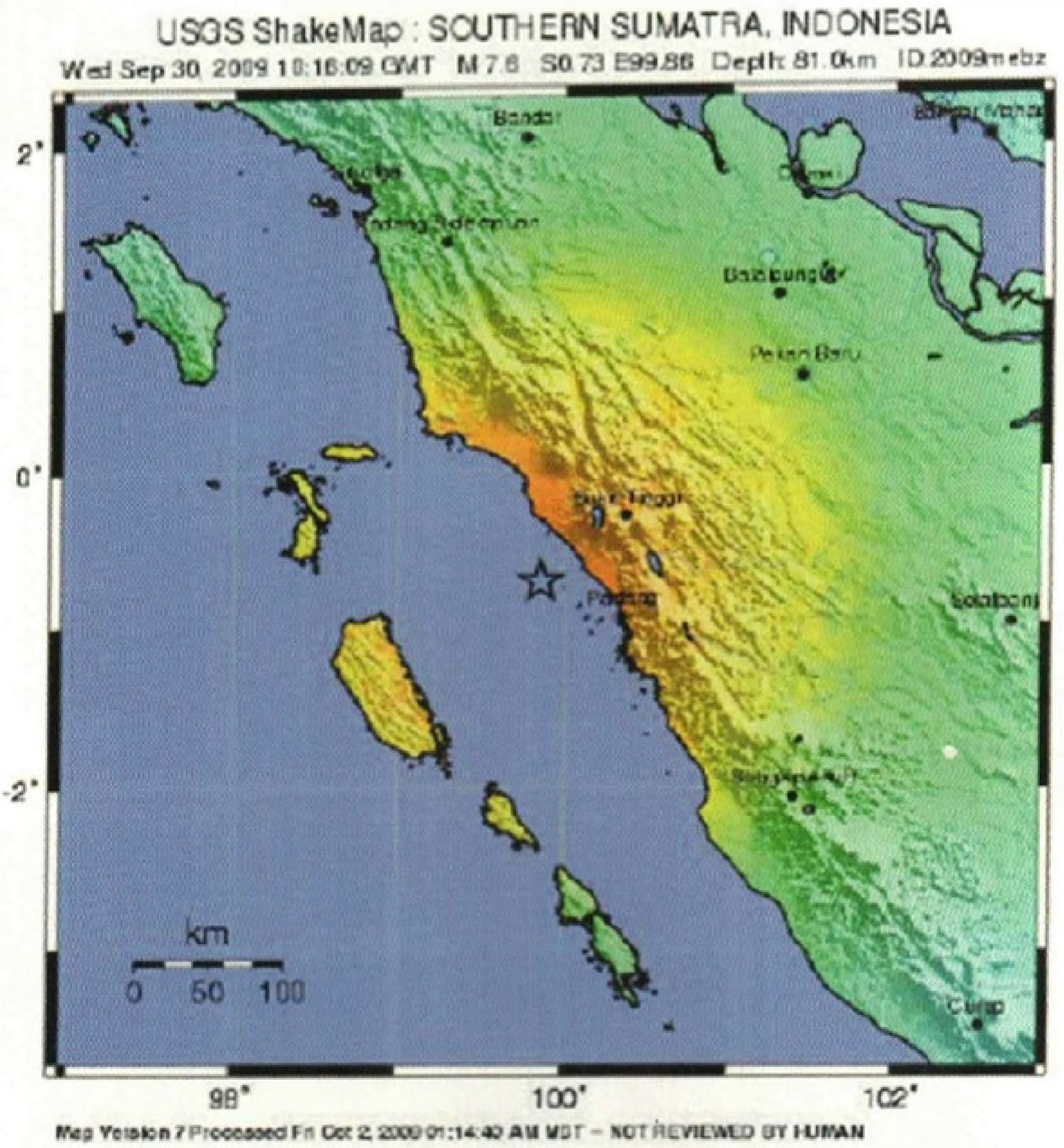


Fig. 4.3 Patches with strong interseismic coupling on the Sunda megathrust, offshore Sumatra, coincide with large seismic ruptures (Konca et al. 2008)

The shaking ground induced landslides and subsequently collapsed slopes at various spots in the mountain areas. As a result, many access roads were cut off, thus creating a significant amount of time to grasp the damage in the affected areas. Extensive landslides in Padang Pariaman resulted in high casualties; three small villages were buried (Fig. 4.5). Observations of the spoil site showed that the pumiceous tuff originating from late eruptions of the Maninjau caldera was light and porous and had little cohesion. Heavy rain over several days before the earthquake probably saturated the ground, increasing the driving force and



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Fig. 4.4 Earthquake intensity map on September 30, 2009 (USGS)

weakening the soil resistance, causing the slope to be marginally stable. The flat lands below the hills at the toe of the hills, consisting mainly of loose silt, sand, and gravel mixtures, may have also lost lateral support and contributed to the massive landslides as well as debris and mud flows (Fig. 4.6). In highland areas, the heavy rain and earthquake caused near-surface loose colluvium to slide (EERI 2009).

Fig. 4.5 Massive landslides occurred in Pariaman: a village below this slide was buried

Fig. 4.6 Debris flows in rural areas northeast of Pariaman

Liquefaction occurred during the quake. Ground amplification of the seismic waves, which was particularly damaging to taller buildings, was reported with a longer natural period. Eyewitnesses described visible ground waves from the earthquake. Most liquefaction and lateral spreading were observed at the area near the coast (Fig. 4.7).

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Fig. 4.7 Lateral spreading affecting the Seafront road (Jalan Samaudra) in Padang

4.2.2 West Java Earthquake

On September 2, 2009, a 7.3-Mw earthquake struck the Tasikmalaya District, West Java Province, at a depth of 30 km. A second 5.1-Mw earthquake followed at 3:15 p.m. at a depth of 38 km. A third 5.4-Mw earthquake struck at 4:28 p.m. at a depth of 15 km. A tsunami warning was issued but was withdrawn 1 h later. Affected districts and municipalities included Bogor, Cianjur, Sukabumi, the municipality of Sukabumi, West Bandung, Bandung, Garut, Banjar, Ciamis, the municipality of Tasikmalaya, and Purwakarta. The shaking was felt widely on Java, with maximum MMI intensities of VII at Tasikmalaya, VI at Cianjur and Sukabumi, V at Bandung, and IV at Jakarta. Figure 4.8 shows the earthquake intensity distribution and the damage level of the affected area; a historical earthquake in West Java is shown in Fig. 4.9 (USGS).

An earthquake induced a huge landslide at Cikangkareng; it buried 12 houses and killed 30 people (Fig. 4.10). The slopes of the region were very steep, about 80–90°, whereas the village was located near the slope. The geologic setting of the region was formed with sedimentary rock that consists of sandstone, tuff, and breccias (Koesmono et al. 1996). During the dry season, the rock weathered and

Fig. 4.8 Earthquake intensity distribution on September 2, 2009 quake off the south coast of West Java (USGS)

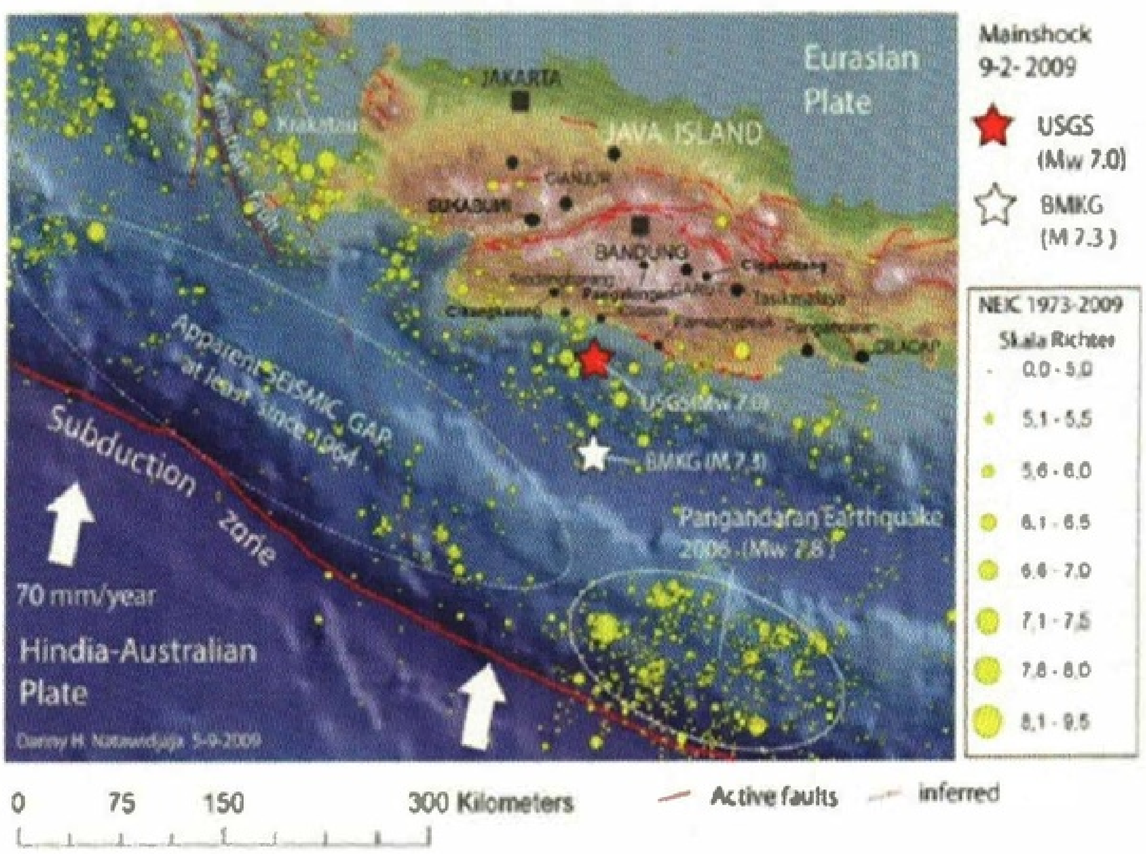

Fig. 4.9 General seismotectonic map of the West Java region (USGS)

Fig. 4.10 Landslide induced by earthquake at Cikangkareng, Cianjur: landslide source (*top*); rock debris materials covered village (*below*)

resulted in sandy silt and sandy clay. A joint was formed and a fissure was found near the ground surface. Consequently, the slopes collapsed easily during ground shaking when the earthquake occurred on September 2, 2009. Landslide materials such as rock and earth fall and flow quite fast and ruin villages (Fig. 4.10).

Liquefaction occurred during the earthquake. The ground shaking triggered mudflow at Pasir Gede, Sukahening village (Fig. 4.11). The area is located at S07° 12′34,6″ and E108°08′08,7″. Based on interviews of local people, similar

Fig. 4.11 Sand boiling at Kp. Pasir gede, Sukahening village, Sukahening, Tasikmalaya

mud flows occurred in 1952 and 1982. According to the geology map (Budhitrina 1986), the mud flow location was laid on volcano sediment, breccia, lahar, and tuff underlain with andesite and basalt from the Talagabodas volcano. There was no fault observed in the mud flow region. However, the quake was possibly caused by a shear joint adjacent the aquifer layers. As a result, the gray color of mud flowed out with water because of pressure from the aquifer.

4.2.3 Lesson Learned

The two deadly earthquakes in September 2009 can act as a warning for the society and government to enhance disaster management preparedness. The disaster management law of the Republic of Indonesia No. 24/2007 contains paradigm shifting about the disaster, including preparedness, emergency response, and rehabilitation and reconstruction. Based on the recent earthquake overview, disaster preparedness was low. According to research on the preparedness index conducted by the Indonesian Institute of Science (LIPI 2007), disaster preparedness in the community was quite low. Household, government, and school communities must become aware of possible disasters and enhance their capacity to manage disaster risk.

It can be learned from the massive landslides in Pariaman and Cingkakareng that the community must be aware of and understand collateral disaster risk. The recent earthquake also pointed out the lack of an earthquake-induced landslide early warning system (ELEWS). At the moment, the community and government focus on a rainfall-induced landslide early warning system. Hence, an integrated landslide warning system needs to be built.

4.3 Collapse of Situ Gintung Dam

4.3.1 Disaster Overview

On Friday morning, March 27, 2009, at 2:00 a.m., the Situ Gintung dam burst in Cirendeu, Ciputat, Tangerang, Banten Province (Fig. 4.12). The dam failure was triggered by torrential rains. The water in the reservoir, about 15-m wave of water, flushed into houses and villages downstream (Fig. 4.12). The dam was originally built by Dutch colonial authorities in 1933. It was made from earth compacted into a wall 16 m high, and the reservoir held at least two million cubic meters of water. The original imperative of the dam had been to retain water for irrigation of rice paddies, which were subsequently replaced by urban development.

Heavy rain was indicated as the triggering factor for the dam failure. On March 26, 2009 at 4.00–7.00 p.m., the nearest rainfall station in Ciputat (Balai II) recorded a rainfall duration of about 4 h, with accumulated rainfall of about 113 mm (BMKG 2009). The rainwater caused the water level in the reservoir suddenly rise. However, overflow of the water could not spill out through outlet tunnel because the spillway and outlet malfunctioned. Consequently, the water overtopped the crest of the earth dam. The overtopping caused some piping and cracks at the toe downstream of the dam. The piping allowed water to infiltrate the capillary breaks that caused the dam to collapse. Piping was also identified by eyewitnesses in December 2008.

Fig. 4.12 Collapse of the Situ Gintung dam on March 27, 2009

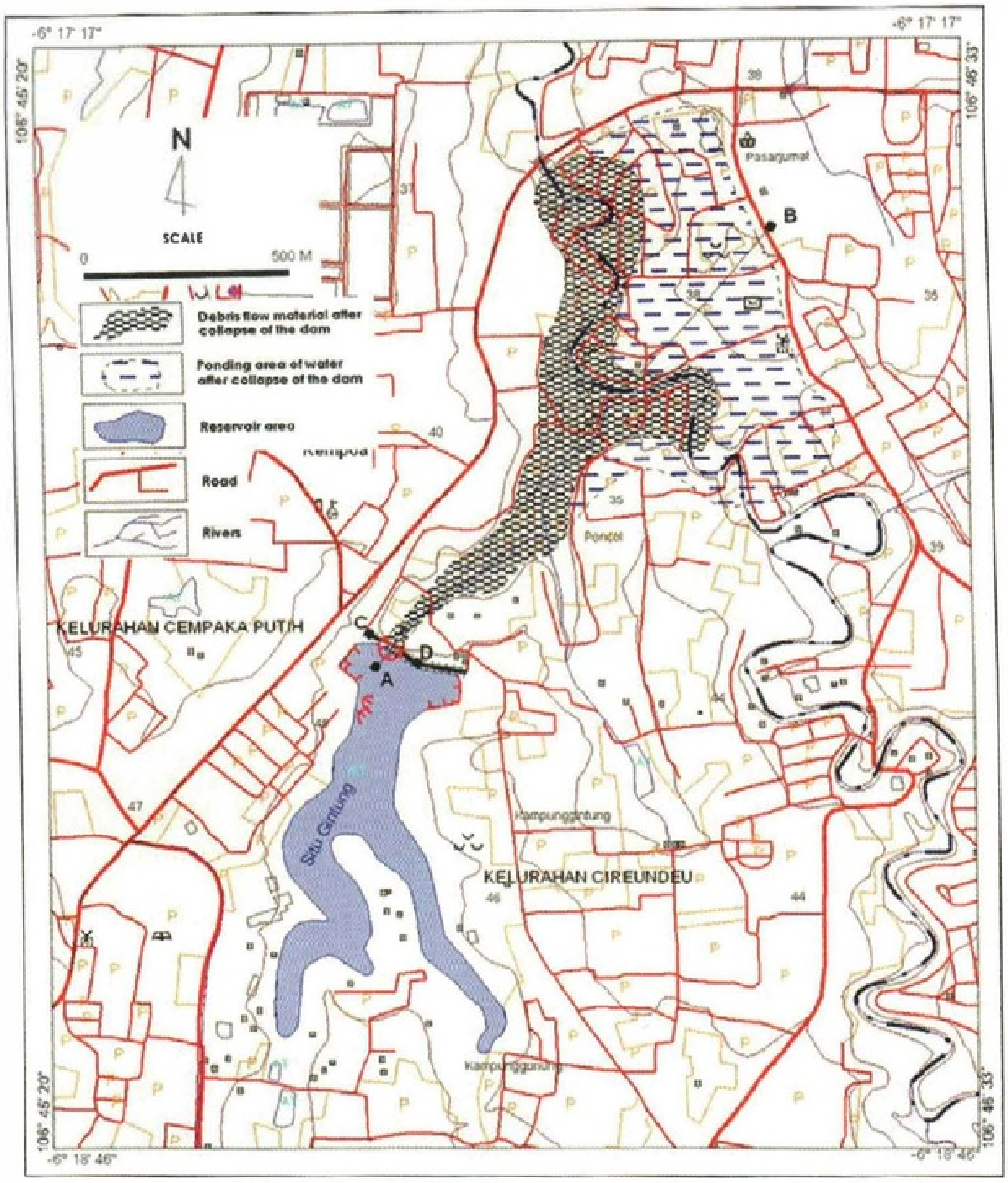

Fig. 4.13 Catchment area of Situ Gintung and the location of debris materials after the collapse of the dam

4.3.2 Lesson Learned

The area surround the Situ Gintung dam has developed into a populated settlement. According to the spatial planning law of the Republic of Indonesia No. 24/1992 or the current spatial planning law No. 26/2007, the Situ Gintung area is supposed to be a conservation area. Assigning the Situ Gintung area as a conservation area means only activities protecting the environmentally sensitive area of Situ Gintung are allowed in the area. Residential buildings are certainly not allowed in conservation areas such as Situ Gintung.

To reduce disaster risk, mitigation has to be implemented continuously. Many dams in Jakarta and other regions are also located in heavily populated areas. An early warning system (EWS) has to be built to reduce the risk. An EWS includes routine maintenance of the dam, improving land use, and spatial planing, empowerment, and participation of the local society (Fig. 4.13).

4.4 Concluding Remarks

The location of Indonesia in the Ring of Fire puts the country at high risk of collateral disaster. The recent earthquakes in West Java and West Sumatera provide insight about collateral hazards. Damage and loss of some settlements and villages in Pariaman and Cingkangkareng caused by massive landslides resulting from earthquakes indicate that the early warning system, including the hazard map, was inadequate. To overcome this problem, establishing research collaboration among governments, universities, and research centers is needed to build an integrated early warning system in Indonesia. Also, when spatial planning, one has to consider the disaster risk area. Although constitutional law about spatial planning and settlement exists, enforcement must be strictly imposed and the rules must be obeyed.

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