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Assessing natural disaster risk in the Asia-Pacific region

Supporting international development through natural hazard risk research

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The Asia–Pacific region experiences some of the world's worst natural hazards–frequent earthquakes, volcanic eruptions, cyclones and annual monsoons. It also includes many of the world's megacities–those with more than 8 million people–so the number of people exposed to hazard risks in the region is very high.

There is abundant evidence that natural disasters disproportionately affect developing countries. Between 1991 and 2005, more than 90% of natural disaster deaths and 98% of people affected by natural disasters were from developing countries (OFDA/CRED International Disasters Database EM-DAT). Moreover, disasters are increasing in number and size every year due to a number of factors including rapid population growth, urbanisation and climate change.

Implications for international aid programs

The high risk of natural disasters in developing nations has considerable implications for international aid programs. Natural disasters can significantly compromise development progress, reduce the effectiveness of aid investments, and halt or slow progress towards the achievement of Millennium Development Goals (MDGs). For example, progress on MDG 1–halving poverty and hunger by 2015–may be halted or reversed during a natural disaster. Furthermore, aid resources may be diverted to humanitarian and emergency responses which can impact on development programs in areas not directly affected by a disaster.

Natural hazard risks also influence the type and scale of disaster relief and humanitarian response required of aid agencies. Relatively infrequent, high-magnitude, natural disasters, such as the December 2004 Indian Ocean tsunami, are most likely to overwhelm the capacities of local and national governments and to require significant international humanitarian assistance.

With increasing recognition that disasters erode hard-won development gains, international policymakers have focused on disaster risk reduction (such as the Hyogo Framework for Action). In line with this trend, the Australian Government, through the Australian Agency for International Development (AusAID), has placed greater emphasis on the reduction of natural hazard risk in developing countries.

Improving our understanding of the frequency, location and magnitude of sudden-onset natural disasters will help the Australian Government and AusAID plan and prepare for natural disaster response (for example, through the strategic placement of emergency supplies). Recognising the impact of disasters on the progress of development, the Australian Government decided in 2007 to enhance the humanitarian response, preparedness and capacity of partner governments. In particular, that decision recognised a need for better natural hazard risk assessments.

In 2007, as part of this strategic approach, Geoscience Australia's Natural Hazard Impacts Project conducted a broad hazard risk assessment of the Asia–Pacific region for AusAID. The assessment included earthquake, volcanic eruption, tsunami, cyclone, flood, landslide and wildfire hazards, with particular attention given to countries the Australian Government considered to be high priority, of interest or of secondary focus (figure 1).

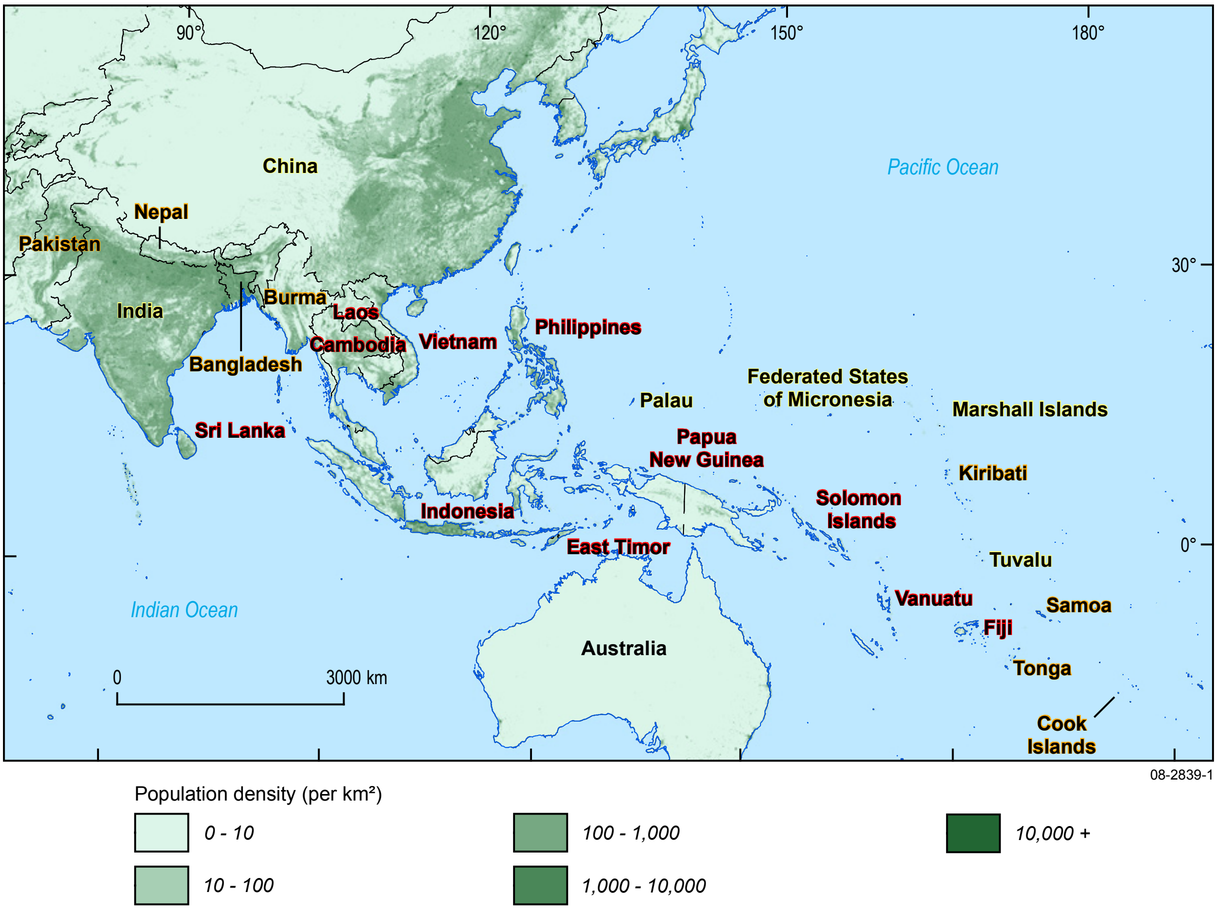

Figure 1. Countries included in this study, colour-coded according to the priority their natural hazard risk was given for the study. Primary focus countries are highlighted in red, countries of interest in orange, and secondary focus countries in pale yellow.

Determining natural hazard risk in a development context

Disasters are not the inevitable consequence of natural hazards. A volcanic eruption on an uninhabited Alaskan island is unlikely to be a disaster, but a similar eruption in the densely populated Asia–Pacific region could be catastrophic.

For a natural hazard to become a natural disaster, populations need to be exposed to the hazard. However, if we analyse disasters, we find that the scale and impact of a natural hazard is determined by inherent vulnerabilities within populations. A magnitude 6 earthquake in New Zealand (such as the 2007 Gisborne earthquake), is unlikely to cause mass fatalities, as that country has strict building codes. Yet an earthquake of the same magnitude could lead to many fatalities in the developing countries of the Asia–Pacific region if building codes are not enforced. To rewrite a familiar adage, 'earthquakes don't kill people, buildings do'.

A crucial aspect in the assessment of natural disaster risk is the metric used to define a previous disaster and therefore the risk of future disasters. While the number of fatalities is the typical metric used to classify disasters, this ignores the number of injured, homeless and displaced people, the need for international humanitarian assistance and the economic impact.

This study uses 'significantly impacted population' as the risk metric. This deliberately vague term covers death, injury, displacement, prolonged loss of access to essential services and/or shelter, and/or significant damage to agriculture, horticulture and industry.

Future work to improve our understanding of natural hazard risk in the Asia–Pacific region will need to test more specific risk metrics, particularly those most useful in an international development and humanitarian context. It could be useful to calculate risk in terms of the number of fatalities and injured, the extent of building destruction, the period of compromised access to essential services (such as water, electricity, communications and health), the impact on food supply (such as effect on the annual harvest) and/or the effect on the economy.

A particularly useful risk metric, and one touched on in our study, is the risk of a government's disaster response capabilities being overwhelmed and requiring external aid assistance. The potential for this is proportional to the percentage of the population seriously affected and the country's level of development.

If a very small proportion of a developed country's population is affected by a disaster, internal resources can be readily mobilised for response and recovery. When cyclone Larry hit northern Queensland, it seriously affected less than one per cent of Australia's population and Australia was well equipped to support those affected without external assistance. In contrast, a similar percentage of Papua New Guinea's population was directly affected by cyclone Guba, but the response required significant foreign support in the post-disaster phase.

A final question concerns the priorities of the international aid community: should we be most concerned about relatively frequent and lower impact hazards, such as the near-annual flooding of the Mekong Delta in Southeast Asia, or comparatively rare but often catastrophic disasters, such as the December 2004 Indian Ocean tsunami? Both types of events seriously compromise development progress, and an all-hazards approach is optimal, but in a reality of limited resources what event has the highest priority?

Natural hazard risk assessment

Geoscience Australia's preliminary natural hazard risk assessment of the region aimed to help AusAID identify countries and areas at high risk from one or more natural hazards. The frequency of a range of sudden-onset natural hazards was determined and, allowing for data constraints, an evaluation was made of potential disaster impact. Extra emphasis was placed on relatively rare but high-impact events, such as the December 2004 tsunami, which might not be well documented in the historical record.

Our assessment suggests that it seems inevitable that the Asia–Pacific region will see one or more 'megadisasters', seriously affecting millions of people, during the 21st century.

Some researchers have predicted that an earthquake with a million fatalities could occur in the Himalayan belt of South Asia and we would argue that megacities in China, Indonesia and the Philippines are also candidates. From the available research, the case for volcanic disasters on that scale has not been argued, but analysis suggests that millions could be seriously affected by a large eruption in the Philippines or Indonesia. Finally, the population explosion in the megadeltas of Asia (for example, Bangladesh), combined with increasing vulnerability to climate change, indicates that a flood or cyclone event affecting tens of millions of people is also likely.

Megacities with a very high earthquake risk

The 18 million residents of Manila in the Philippines dwell in an area particularly vulnerable to earthquakes—the city has sustained heavy damage

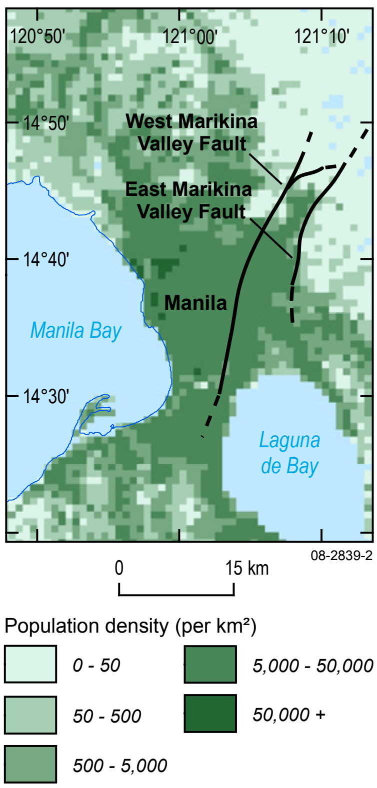

Figure 2. The convergence of high population density and active faults in Manila, the Philippines. Movement on the Marikina Valley fault could have a devastating impact on Manila, depending on the earthquake magnitude and epicentre. Population data are from Landscan, with more intense colour signifying higher population density. The fault location is from Nelson et al (2000).

from earthquakes at least six times in the past 400 years (Nelson et al 2000). In part, this results from movement on the Marikina Valley fault system, which cuts through the northeastern part of the city (figure 2). Studies suggest that magnitude 6–7 earthquakes are generated on this fault every 200 to 400 years (Nelson et al 2000).

A combination of rapid urbanisation, location on a floodplain prone to amplified ground motion and liquefaction, and frequent large earthquakes results in a high potential for an earthquake to impact on a large proportion of Manila's population. Indeed, our analysis suggests that Manila is the Asia–Pacific megacity most at risk to earthquakes, with magnitude 5 earthquakes occurring on average once every 37 years. A magnitude 5 earthquake centred near Manila is predicted to significantly impact on several hundreds of thousands of people; a larger earthquake striking at Manila's centre could be catastrophic.

"With increasing recognition that disasters erode hard-won development gains, international policymakers have focused on disaster risk reduction."

Across the Asia–Pacific region, the countries with the largest total populations exposed to very high earthquake hazard are China, India, Nepal, the Philippines and Burma, while other megacities with a particularly high risk from earthquakes include Dhaka (Bangladesh) and Beijing. Countries with a high percentage of their populations exposed to very high earthquake hazard are Vanuatu, Solomon Islands, Nepal, Burma and the Philippines.

Potential impact of dormant volcanoes

'The most dangerous situation of all is that of a large, unexpected explosive eruption from a long-dormant volcano in a densely populated area'(Simkin 1993).

Our analysis suggests that 180 million people in the Asia–Pacific region live within 50 kilometres of a volcano that has not been active in the past 40 years. Consequently, the 'dangerous situation' referred to by Simkin (1993) is prevalent in the region.

To illustrate the potential impact of one of these long-dormant volcanoes erupting in the densely populated Asia–Pacific region, Geoscience Australia developed a simple simulation of the impact of Indonesia's Tambora eruption on today's population. The 1815 eruption of Tambora volcano, 300 kilometres east of Bali, killed around 92 000 people. With the growth of population during the 20th century, the impact of the same eruption today would be catastrophic. This is illustrated by the following scenario, which uses ash thicknesses from Self et al (1984).

If the warning signs of an impending eruption were recognised and appropriate action taken, more than 200 000 people would require evacuation from within 50 kilometres of the volcano. The evacuation would provide protection from the most life-threatening of volcanic hazards.

Assuming wind patterns similar to those during the 1815 eruption, around 8 million people would be within range of deposits of at least 20 centimetres of ash during the eruption, potentially collapsing around one-third of roofs. Roughly one-third of Indonesia's population would be within range of deposits of one centimetre of ash (figure 3). This relatively thin layer could damage electrical equipment, disrupt power supplies, contaminate water sources, cause health problems and significantly interrupt food production, industry and tourism. In addition, at least one tsunami was triggered by the 1815 eruption, with a wave height of 4 metres near the volcano and 1–2 metres in East Java (Stothers 1984). Such a tsunami today could cause extensive coastal damage.

Similar eruption scenarios could be played out in many Asia–Pacific countries, with

Figure 3. The current population density of Indonesia overlaid by the ash-dispersal pattern from the 1815 Tambora eruption. The area 100 kilometres from the volcano received between 50 and 100 centimetres of ash, and pyroclastic flows are thought to have extended about 30 kilometres from the volcano. More than 500 000 square kilometres of the Java Sea and surrounding islands were covered by more than one centimetre of ash. Eruption details from Self et al (1984).

Indonesia and the Philippines having the greatest number of people exposed to very high volcanic hazards. Geoscience Australia's analysis suggests that volcanic disasters seriously affecting more than 100 000 people can be expected about once a decade in Indonesia and once every few decades in the Philippines. Volcanic disasters impacting on tens of thousands of people in Papua New Guinea are expected about once a century, while Vanuatu has the potential for a catastrophic volcanic disaster (one that affects at least one per cent of the population) about twice in a century.

Low-lying coastal areas exposed to potential large tsunamis

The December 2004 Indian Ocean tsunami provided a catastrophic reminder that the Asia–Pacific region is far from immune to tsunami. The region is traversed by one-third of the world's subduction zones, capable of producing the world's largest earthquakes and tsunamis. Furthermore, many of the subduction zones are adjacent to densely populated low-lying coastal communities.

Geoscience Australia's broad assessment focused on the largest earthquakes (magnitude 9.0 to 9.5) generated in the subduction zones of the region at a frequency of around one in 1000 years. The number of people exposed to tsunamis was determined by using a very coarse relationship between earthquake magnitude, proximity of affected coastlines, and populations living close to sea level.

The results suggest that the most dangerous potential source of large tsunamis is at the northern tip of the Bay of Bengal. A tsunami there would threaten several million people in the low-lying coastal areas of Bangladesh, India and Burma. By individual country, Indonesia has the highest population threatened by tsunamis, followed by Bangladesh and India.

While Pacific nations have considerably lower population densities, very high percentages of their populations would be impacted by a tsunami generated from nearby subduction zones. Up to 40% of Vanuatu's population would be at risk in the event of a tsunami, followed by more than 20% in Tonga. Many other Pacific island nations have more than 5% of their populations similarly exposed.

Conclusion

Our preliminary assessment of natural hazard risk in the Asia–Pacific region highlights the potential for the region to experience a megadisaster affecting millions of people during the coming century.

While the scale of such a disaster may seem greater than any recorded so far, we reached this conclusion not only because the Asia–Pacific region is home to intense geological and meteorological activity, but also because of the region's burgeoning population, which has increased more than fivefold during the 20th century. People in the region are increasingly vulnerable because of trends such as rapid urbanisation and their tendency to concentrate in areas especially prone to natural hazards.

Because of the threat natural disasters pose to the progress of development, natural hazard risk management will continue to increase in importance in international development policy in the Asia–Pacific region.

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