Chapter 3

Intensive Riskscapes

Patterns of intensive risk have developed along the fault lines of four decades of economic development and globalisation. The potential consequences of these risks can now be estimated and visualized. A first ever global probabilistic assessment allows for a better understanding of intensive risk for earthquakes and cyclonic winds.

The results from the global assessment are a wake-up call: global average annual losses from earthquakes alone are estimated to exceed US$100 billion. Of these, 80 percent are concentrated in high-income countries. Probable maximum losses for Japan and the United States of America in the case of a catastrophic one-in-250 year earthquake are over US$100 billion. In these countries, high exposure is the key driver of disaster risk.

Vulnerability continues to determine risk levels, particularly in low and middle-income countries. Philippines and Puerto Rico could lose more than 15 percent of their exposed capital stock to winds from a catastrophic one-in-250 year tropical cyclone.

Roughly 80 percent of cyclonic wind risk is concentrated in Asia. The continent also has significant tsunami exposure, with Japan leading in both absolute and relative exposure of its people. However, smaller economies, including many SIDS, can expect higher losses relative to their capital stock for all hazards

3.1 The past is not a good guide to the future

No two disasters are alike. Along a major earthquake fault line, in a large river basin or along a coastline, an infinite number of hazard events could occur. However, most of these have yet to happen. Therefore, although patterns and trends of disaster loss provide a guide to the past, they are often not sufficient to predict and estimate losses that may occur at present and in the future.

Historical records may provide information on hazard events that have occurred, even over several hundred years. However, in any given location, many events, particularly extreme events that only occur every thousand years or so have yet to materialise. In order to explore future risks, therefore, it is necessary to look beyond historical losses.

For GAR13, a probabilistic approach to risk modelling has been adopted. This approach estimates the probability of events of different severity occurring in a given location, including extreme and infrequent events that have not yet occurred (or which we have no records of), but which could potentially occur in future. Historical losses are integrated into this model, as they are an important source of information.

Of interest to investors and businesses exploring new terrain, a new global analysis, carried out for the GAR, is beginning to map the contours of this risk landscape. The objective of the GAR global risk model is to provide comparable disaster risk metrics for all countries and territories in the world.

As Figure 3.1 highlights, initial global risk estimates for earthquakes and cyclonic winds and an improved estimate for tsunami exposure are now available.

At present, the estimates refer to the risk of direct loss to urban produced capital[i] and are agglomerated at the country level.[ii] The model does not estimate the risks of indirect loss owing to business in-

Figure 3.1 GAR Global Risk Model deliverables for 2013 and 2015

Hazard Type		GAR 13		GAR 15	
		Output	Scale	Output	Scale
Earthquakes		AAL and PML 250	Global	AAL and PML multiple	Global
Tsunami		Exposure	Global	PML multiple	Global
Cyclones	Winds	AAL and PML 250	Global	AAL and PML multiple	Global
	Storm Surges	-	-	AAL and PML multiple	Global
Floods	River Flood	AAL	Thailand	AAL and PML multiple	Global
	Ponding Flood	AAL and PML 250	Caribbean	AAL and PML multiple	To be confirmed
Volcanic Ash		-	-	Exposure	Global

AAL = Annual Average Losses
PML250 = Probable Maximum Losses for 250 years return period

(Source: UNISDR)

terruption, risks to agriculture, forestry or other rural sectors nor mortality and injury.

By quantifying the value of urban produced capital exposed to each potential hazard event that could occur in each location, and by assessing its likely vulnerability, it is then possible to estimate the probability of how much disaster loss could occur in a given time period.

Maximum losses associated with events of specific return periods are described as probable maximum losses (PML): for example, the maximum loss that might occur once every 250 years would reflect a 0.4 percent probability of the loss occurring in any given year. When PML for all events that could occur are averaged over a long period, then annual average loss (AAL) can be calculated.

Depending on the hazard profile of a country, the AAL represents the probability of both frequently occurring losses, for example, with return periods of five or ten years, as well as highly infrequent losses that may occur, for example, once every thousand years. For that reason, AAL should not be confused with the average observed losses that have occurred, even if records go back a century or more. A country may have a relatively high AAL—from earthquakes, for example—if catastrophic loss is expected from a rare thousand-year event, even though there may be no recorded earthquake loss over the last 100 years.

Annex 1 provides a technical description of how the new GAR global risk model is being developed.

Risk estimates are computed using highly simplified global hazard models, a proxy for the exposure of urban produced capital and a standardised global set of vulnerability curves. Owing to the simplification inherent to global modelling and to the limitations of the current input data on hazard, exposure and vulnerability, the estimates obtained from the model have an intrinsic degree of error and uncertainty. As such, estimates are presented as a set of risk classes rather than as absolute numbers and represent the likely order of magnitude of loss.

Given that the estimates are calculated using the same methodology and with consistent global level proxy data, risk classes are internally coherent at the global level and provide a point of comparison between risk levels in countries and territories. These risk classes should be considered as starting points to understand the degree of possible annual losses for a country, enabling a government to discuss which disaster risk management strategies are most appropriate for its risk profile. The risk classes may also help investors to understand the degree of risk faced by different countries.

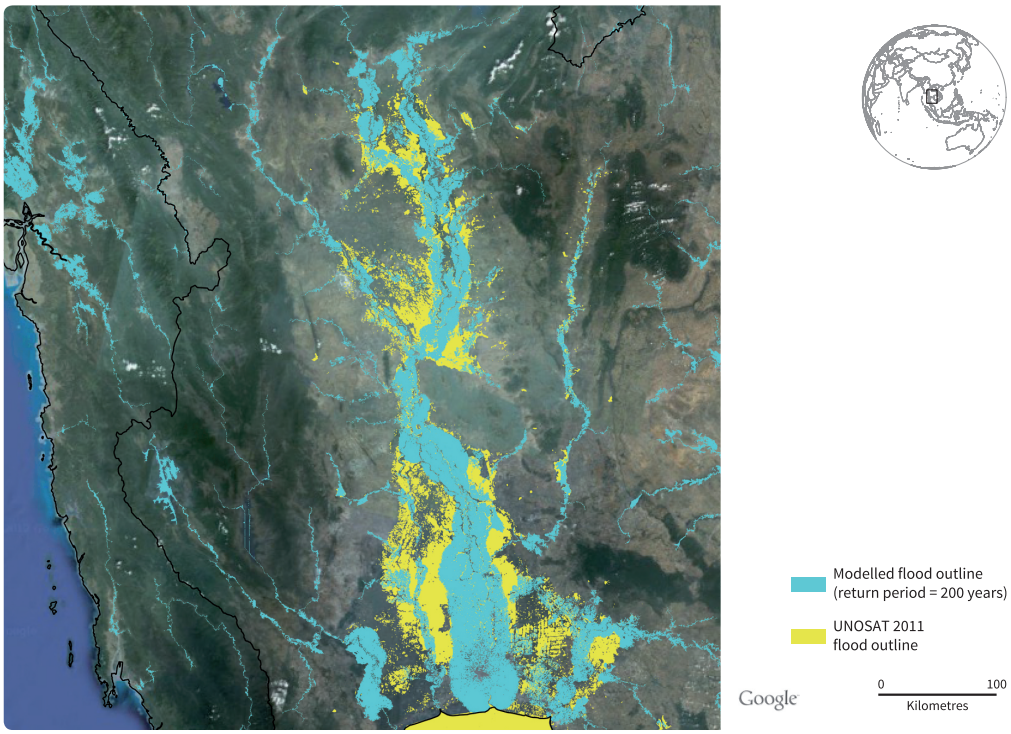
However, the results are unlikely to be comparable with national or local AAL and PML estimates calculated with detailed hazard, exposure and vulnerability data or for specific portfolios of insured assets. This should not be considered a defect of the model. However much it is enhanced, a global model can never provide nor substitute for the detailed risk estimates required for designing national and local risk reduction investments or insurance schemes. However, the estimates provided by the global model may encourage governments to develop the more specific risk models required to implement disaster risk reduction.

The development of the global model is iterative and the current release should be considered as a starting point. Between 2013 and 2015, the different hazard models, exposure proxy and vulnerability curves will be enhanced and further developed, taking into account peer review and the best available

Box 3.1 Proof of concept for the GAR flood model

While river floods will not be included in the GAR risk model until 2015, a national level proof-of-concept study shows promising results. As Figure 3.2 shows, in Thailand, modelled results were compared with the outcomes of the Chao Phaya river floods of 2011.

Figure 3.2 Flood hazard for Thailand compared with actual flood footprint of 2011



(Source: GAR global flood model; UNOSAT[iii])

The modelled results were largely coherent with the maximum flood depths of between 3 metres and 4 metres recorded in different sites upstream from Bangkok.

(Source: UNISDR)

science and data to provide greater accuracy. By 2015, the model should also include global risk estimates for flooding, storm surges, volcanic ash and tsunamis. Box 3.1 presents a proof of concept for the global flood model.

3.2 Earthquake risk

Absolute earthquake risk is concentrated in high-income countries. But many small and low-income countries have a higher proportion of their urban produced capital at risk.

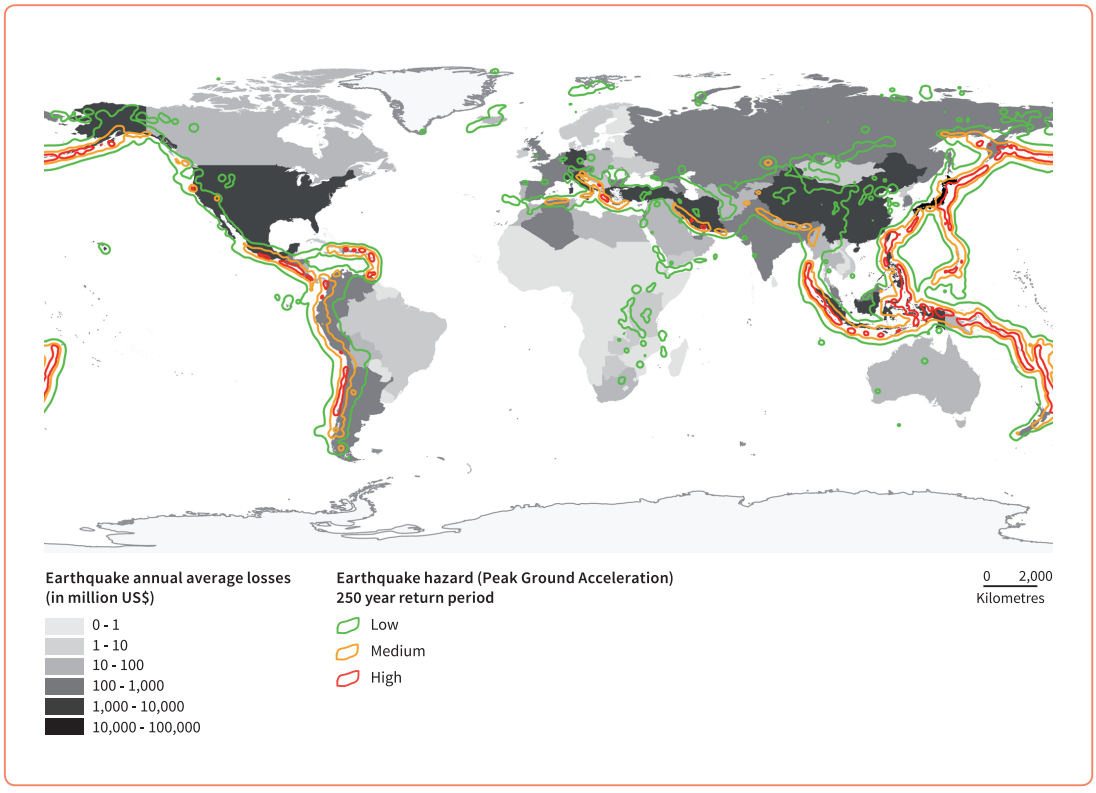
Total global annual average loss (AAL) for earthquakes is estimated at more than US$100 billion. As Figure 3.3 shows, these economic risks are highly concentrated in countries with large volumes of exposed produced capital and high earthquake hazard.

As highlighted in the previous chapter, given investment decisions and capital flows, global produced capital remains heavily concentrated in high-income countries. Therefore, the highest absolute levels of earthquake risk are also found in these countries, which is where approximately 80 percent of global AAL is concentrated.

In terms of regional distribution, about 76 percent of total global earthquake AAL is concentrated in Asia, 9 percent in Europe, 8 percent in North America and 5 percent in Latin America.

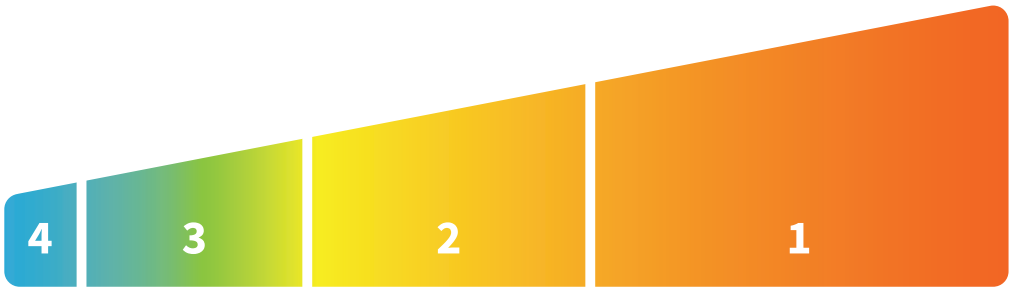
Figure 3.4 shows the distribution of earthquake AAL for countries in different risk classes. For example, the value of urban produced capital in Japan and

Figure 3.3 Annual average loss (AAL) from earthquakes and earthquake hazard (250 year return period)



(Source: GAR global risk model)

Figure 3.4 Annual average losses from earthquakes by risk class



1 = 10,000 to 100,000 million US$
Japan

2 = 1,000 to 10,000 million US$
China, Germany, Greece, Indonesia, Iran (Islamic Republic of), Italy, Mexico, Philippines, Taiwan Province of China, Turkey, United States of America

3 = 100 to 1,000 million US$
Algeria, Argentina, Austria, Azerbaijan, Bangladesh, Belgium, Bulgaria, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, France, Guadeloupe, Guatemala, Honduras, India, Israel, Kazakhstan, Kuwait, Malaysia, Netherlands, New Zealand, Pakistan, Peru, Puerto Rico, Republic of Korea, Russian Federation, Singapore, Spain, Switzerland, Trinidad and Tobago, United Kingdom of Great Britain and Northern Ireland, United Arab Emirates, Uzbekistan, Venezuela (Bolivarian Republic of)

4 = 10 to 100 million US$
Afghanistan, Albania, Antigua and Barbuda, Armenia, Australia, Bahrain, Barbados, Bolivia (Plurinational State of), Canada, Croatia, Cyprus, Czech Republic, Egypt, Georgia, Haiti, Hong Kong Special Administrative Region of China, Hungary, Iceland, Iraq, Jamaica, Jordan, Kyrgyzstan, Lebanon, Libya, Malta, Martinique, Morocco, Myanmar, Nepal, New Caledonia, Nicaragua, Oman, Panama, Papua New Guinea, Poland, Portugal, Qatar, Saudi Arabia, Slovakia, Slovenia, Solomon Islands, South Africa, Syrian Arab Republic, Tajikistan, Thailand, Tunisia, Turkmenistan, Vanuatu

(Source: UNISDR, based on GAR global risk model)

the United States of America is US$14 trillion and US$22 trillion, respectively, representing 15 percent and 22 percent each of global urban produced capital. However, although about 100 percent of Japan's produced capital would be exposed to a 250 year earthquake, only about 34 percent of the produced capital of the United States of America would be exposed. Therefore, the AAL of Japan is an order of magnitude higher than the AAL of the United States of America.

Some middle-income countries, such as China, Iran (Islamic Republic of) and the Philippines, also have high levels of risk because their exposed produced capital is more vulnerable than in high-income countries, for example due to weaker building structure and material. The impact that this has on expected AAL highlights the risks of making business investments in countries with higher levels of vulnerability an important consideration for investors.

Although estimates of absolute loss are important, the impact of an earthquake on a country's economy will depend on the proportion of its urban produced capital that could be affected. Figure 3.5 shows that many low and middle-income and smaller countries can be expected to lose a higher proportion of their urban produced capital, which in turn could be expected to generate serious indirect losses for business and macroeconomic effects.[iv]

For example, the absolute value of AAL for countries such as Papua New Guinea and Vanuatu is low compared with other countries (between US$10 and 100 million), but this value represents between 1 percent and 10 percent of these countries' total urban produced capital. In contrast, for the United States of America and China, expected annual average losses, although totalling between US$1,000 and 10,000 million, represent only 0.01 percent to 0.1 percent of their total urban produced capital.

Figure 3.5 Annual average losses from earthquakes as a percentage of urban produced capital by risk class

1 = 1 - 10%
Dominica, El Salvador, Honduras, Philippines, Papua New Guinea, Solomon Islands, Tonga, Trinidad and Tobago, Vanuatu

2 = 0.1 - 1%
Algeria, Aruba, Afghanistan, Albania, Armenia, Antigua and Barbuda, Azerbaijan, Belize, Bangladesh, Barbados, Bhutan, Bolivia (Plurinational State of), British Virgin Islands, Burundi, Bulgaria, Chile, Colombia, Costa Rica, Cyprus, Dominican Republic, Ecuador, Fiji, Georgia, Guadeloupe, Greece, Grenada, Guatemala, Haiti, Indonesia, Iran (Islamic Republic of), Iraq, Italy, Japan, Kyrgyzstan, Myanmar, Martinique, New Caledonia, Nicaragua, Nepal, Pakistan, Panama, Peru, Puerto Rico, Samoa, San Marino, Taiwan Province of China, Tajikistan, Turkmenistan, Turkey, Saint Vincent and the Grenadines, United Arab Emirates, United States Virgin Islands, Uzbekistan

3 = 0.01 - 0.1%
Anguilla, Argentina, Austria, Belgium, Bahrain, Bosnia and Herzegovina, Brunei Darussalam, China, Comoros, Cuba, Cayman Islands, Czech Republic, Democratic Republic of the Congo, Dem People's Republic of Korea, Djibouti, Egypt, Germany, Gibraltar, Croatia, Hungary, India, Iceland, Israel, Jamaica, Jordan, Kazakhstan, Kenya, Kuwait, Lao People's Democratic Republic, Lebanon, Libya, Liechtenstein, Lesotho, Malta, Malawi, Malaysia, Mayotte, Morocco, Monaco, Mexico, Montenegro, Mongolia, New Zealand, Oman, Palau, Qatar, Republic of Moldova, Rwanda, Saint Lucia, Saudi Arabia, Singapore, Serbia, Slovakia, Slovenia, South Africa, Switzerland, Syrian Arab Republic, Turks and Caicos Islands, Thailand, The former Yugoslav Republic of Macedonia, Tunisia, Uganda, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, United States of America, Venezuela (Bolivarian Republic of), Yemen, Zambia

(Source: UNISDR, based on GAR global risk model)

Probable maximum losses for a one-in-250 year earthquake have been estimated both in absolute terms as well as relative to countries' urban produced capital. Although there is only a 0.4 percent probability of these losses occurring in any given year, these values are indicative of the potential extent of losses owing to catastrophic earthquake events. As expected, countries with highest probable maximum losses are Japan and the United States of America—with more than US$100 billion. Countries such as Iran (Islamic Republic of) and China follow closely behind, possibly incurring earthquake losses of more than US$10 billion.

Comparing these expected losses with total urban produced capital provides an indication on what the impact of an event would be on a country's assets. For example, in the Philippines they would correspond to almost 19 percent of its total urban produced capital. Haiti faces losses of more than 25 percent of its urban produced capital again indicating the possibility of a serious impact on business and the economy as a whole. Some small-island developing states, such as the Solomon Islands, risk losing over 40 percent of the value of their exposed capital in a catastrophic quake.

Vulnerability also remains a key determinant of earthquake risk levels. If countries with similar values of exposed capital are compared, the assets of countries with higher PML are likely to be more vulnerable.

For example, probable losses for Spain and Hong Kong (Special Administrative Region of China), with a high value of exposed urban produced capital (about US$1.9 trillion and US$1.1 trillion, respectively) are lower than losses for Iran (Islamic Republic of) and Haiti, which have a significantly lower value of exposed capital (US$0.7 trillion and US$8.5 billion, respectively). These results reflect the much higher

Figure 3.6 Probable maximum losses from earthquakes as a percentage of exposed urban produced capital (250 year return period)

1 = 40 - 60%
Bahamas, Solomon Islands

2 = 20 - 40%
British Virgin Islands, Dominica, Haiti, Tonga, Trinidad and Tobago, Vanuatu

3 = 10 - 20%
Antigua and Barbuda, Barbados, Bhutan, El Salvador, Grenada, Guadeloupe, Honduras, Martinique, Nepal, Philippines, Saint Vincent and the Grenadines, San Marino

4 = 1 - 10%
Afghanistan, Albania, Algeria, Angola, Anguilla, Argentina, Armenia, Aruba, Austria, Azerbaijan, Bangladesh, Belize, Bolivia (Plurinational State of), Bulgaria, Burundi, Cayman Islands, Chile, Colombia, Comoros, Congo, Costa Rica, Croatia, Cyprus, Djibouti, Dominican Republic, Ecuador, Fiji, Georgia, Gibraltar, Greece, Guatemala, Iceland, Indonesia, Iran (Islamic Republic of), Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lebanon, Liechtenstein, Malawi, Malta, Mexico, Monaco, Montenegro, Myanmar, Namibia, New Caledonia, Nicaragua, Pakistan, Palau, Panama, Papua New Guinea, Peru, Puerto Rico, Rwanda, Saint Lucia, Samoa, Slovenia, Switzerland, Syrian Arab Republic, Taiwan Province of China, Tajikistan, The former Yugoslav Republic of Macedonia, Tunisia, Turkey, Turkmenistan, Turks and Caicos Islands, United Arab Emirates, United Republic of Tanzania, United States of America, United States Virgin Islands, Uzbekistan, Venezuela (Bolivarian Republic of), Yemen

(Source: UNISDR, based on GAR global risk model)

vulnerability of exposed assets in Iran (Islamic Republic of) and Haiti compared with exposed assets in Spain and Hong Kong (Special Administrative Region of China) (Figure 3.6).

3.3 Risk from cyclonic winds

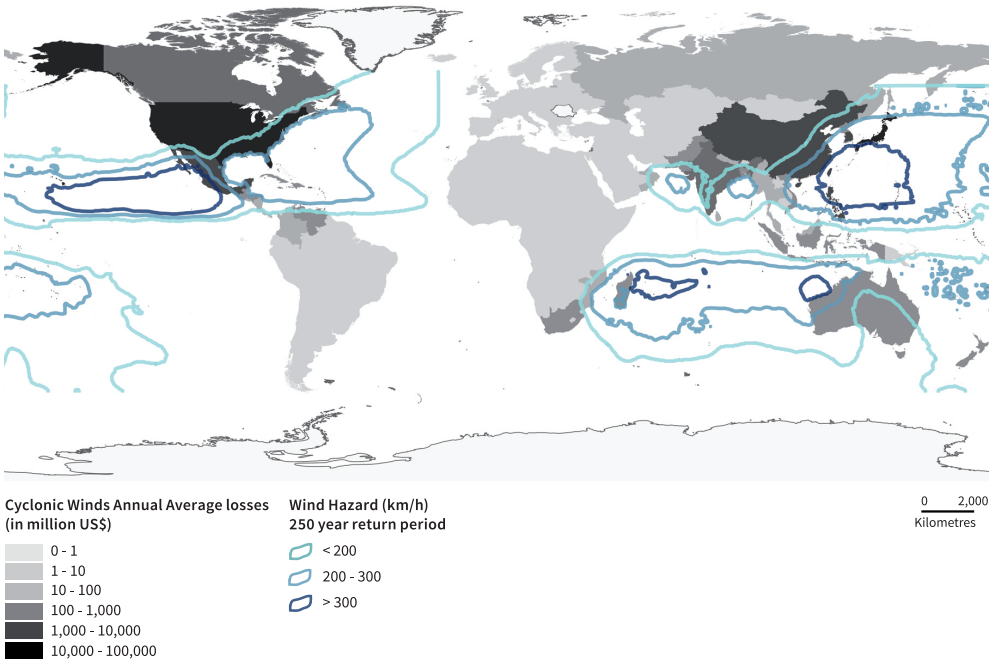
As in the case of earthquakes, expected economic damage from tropical cyclone wind is mainly concentrated in high-income countries and in Asia. However, in relative terms smaller countries, such as SIDS could be expected to lose a far higher proportion of their assets. In many low and middle-income countries, risk is heavily conditioned by vulnerability.

Global annual average losses from cyclonic winds are estimated to be over US$80 billion. Currently, the risk model does not include losses owing to storm surges or coastal flooding but only wind damage. However, it does estimate the losses incurred as cyclones in tropical areas move southward or northwards (depending on the hemisphere) and become sub-tropical or extra-tropical storms (as in the case of Sandy in 2012, for example). At present the tropical cyclonic wind hazard model may have a greater degree of uncertainty and error than the earthquake hazard model and will be further validated and enhanced for GAR15.

Figure 3.7 shows the geographical distribution of the risk. About 80 percent of the risk from cyclonic winds is concentrated in Asia, 13 percent in North America, 4 percent in Latin America and about 2 percent in the Caribbean.

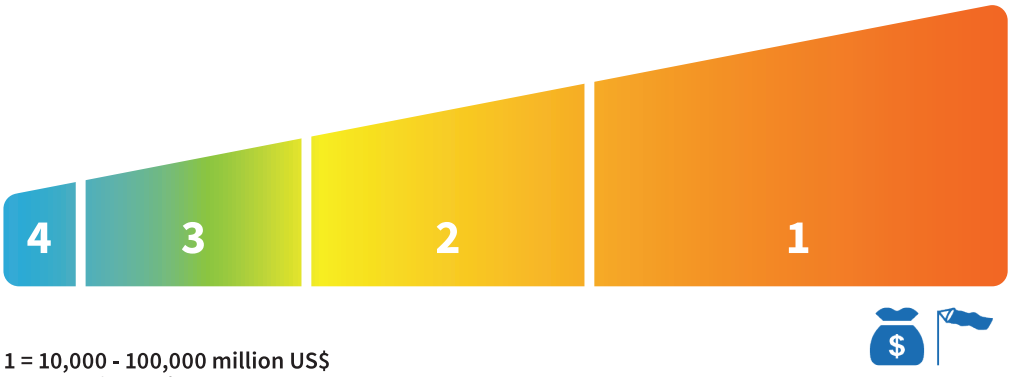
In terms of absolute losses, about 82 percent of risk is concentrated in high-income countries, corre-

Figure 3.7 Annual average losses from cyclonic winds and tropical cyclone wind hazard (250 year return period)



(Source: GAR global risk model)

Figure 3.8 Annual average losses from cyclonic winds by risk class



1 = 10,000 - 100,000 million US$
Japan, United States of America

2 = 1,000 - 10,000 million US$
China, Mexico, Philippines, Republic of Korea, Taiwan Province of China

3 = 100 - 1,000 million US$
Canada, Guadeloupe, Hong Kong Special Administrative Region of China, India, Martinique, Puerto Rico, Réunion

4 = 10 - 100 million US$
Antigua and Barbuda, Aruba, Australia, Bahamas, Bangladesh, Barbados, Brunei Darussalam, Cayman Islands, Cuba, Democratic People's Republic of Korea, Dominican Republic, Fiji, French Polynesia, Guatemala, Haiti, Honduras, Indonesia, Jamaica, Macao Special Administrative Region of China, Madagascar, Mauritius, New Zealand, Pakistan, South Africa, Trinidad and Tobago, United States Virgin Islands, Venezuela (Bolivarian Republic of), Viet Nam

(Source: UNISDR, based on GAR global risk model)

Figure 3.9 Annual average losses from cyclonic winds compared with urban produced capital

1 = 1 - 10%
Cayman Islands, Philippines, Turks and Caicos Islands

2 = 0.1 - 1%
Aruba, Antigua and Barbuda, Bahamas, Belize, Barbados, British Virgin Islands, China, Comoros, Dominica, Fiji, French Polynesia, Guadeloupe, Grenada, Honduras, Haiti, Jamaica, Japan, Madagascar, Mexico, Micronesia (Federated States of), Mozambique, Martinique, Mauritius, Mayotte, Palau, Puerto Rico, Republic of Korea, Réunion, Tonga, Taiwan Province of China, Saint Vincent and the Grenadines, United States Virgin Islands, Vanuatu, Samoa

3 = 0.01 - 0.1%
Anguilla, Bangladesh, Brunei Darussalam, Canada, Cuba, Democratic People's Republic of Korea, Dominican Republic, Guatemala, Hong Kong Special Administrative Region of China, India, Lao People's Democratic Republic, Saint Lucia, Macao Special Administrative Region of China, Myanmar, Malawi, New Caledonia, Nicaragua, Nepal, New Zealand, Pakistan, Solomon Islands, El Salvador, Seychelles, Trinidad and Tobago, United States of America, Venezuela (Bolivarian Republic of), Viet Nam

(Source: UNISDR, based on GAR global risk model)

Figure 3.10 Probable maximum losses from cyclonic winds (250 year return period) compared with the exposed urban produced capital

1 = 20 - 40%
Belize, British Virgin Islands, Cayman Islands, Guadeloupe, Martinique,
Samoa, South Africa, Tonga, Turks and Caicos Islands, United States Virgin Islands

2 = 10 - 20%
Antigua and Barbuda, Bahamas, Barbados, Comoros, Dominica, Fiji, French Polynesia, Haiti, Honduras, Madagascar, Mauritius, Mayotte, Micronesia (Federated States of), Philippines, Puerto Rico, Réunion, Zimbabwe

3 = 1 - 10%
Anguilla, Aruba, Bangladesh, Brunei Darussalam, Canada, China, Cuba, Democratic People's Republic of Korea, Dominican Republic, Grenada, Guatemala, Hong Kong Special Administrative Region of China, India, Indonesia, Iran (Islamic Republic of), Jamaica, Japan, Macao Special Administrative Region of China, Malawi, Malaysia, Mexico, Mozambique, Nicaragua, Pakistan, Palau, Panama, Republic of Korea, Saint Lucia, Saint Vincent and the Grenadines, Seychelles, Solomon Islands, Taiwan Province of China, Trinidad and Tobago, United Arab Emirates, United States of America, Vanuatu

(Source: UNISDR, based on GAR global risk model)

sponding to the highest concentration of urban produced capital. Middle-income countries concentrate 18 percent of risk from cyclonic winds, corresponding to about US$16 billion. Distribution of AAL across countries by risk class is shown in Figure 3.8.

Japan and the United States of America concentrate 56 percent of global risk from cyclonic winds, corresponding to the high value of their exposed capital.[v] Urban produced capital exposed to cyclonic winds[vi] in Japan and the United States of America is valued at about US$14 trillion and US$11.6 trillion, respectively. This corresponds to 100 percent and 52 percent, respectively, of total urban produced capital of both countries.

Middle-income countries such as China, Mexico and the Philippines all have high AAL in terms of absolute value. However, in relation to the countries' produced capital, the losses vary significantly: although the AAL for China and Mexico corresponds to about 0.2 percent of the country's urban produced capital, the AAL for the Philippines corresponds to more than 1 percent of the country's total produced capital (Figure 3.9).

Absolute probable maximum losses from a catastrophic one-in-250 year cyclone are also estimated to be significant, particularly for countries with high asset exposure.

When calculated as a percentage of total urban produced capital, the probable maximum losses from such as catastrophic event become particularly threatening to small countries. For example, countries such as Belize, Guadeloupe, Martinique and Samoa could lose between 20 percent and 40 percent of their total urban produced capital from cyclonic wind disasters (Figure 3.10).

As in the case of earthquakes expected losses are also influenced by vulnerability. For example, in terms of absolute probable maximum losses, countries and territories such as Hong Kong (Special Administrative Region of China), the Philippines and Puerto Rico are in the same risk class. However, in relative terms, Hong Kong (Special Administrative Region of China) faces losses of only 2 percent, whereas the Philippines and Puerto Rico face losses of more than 15 percent of their exposed capital.

3.4 Tsunami exposure

Exposure to tsunamis is a good proxy for the risk associated with highly destructive one-in-500 year tsunamis. Japan has the highest exposure of produced capital in absolute terms and the third highest in relative terms but many smaller countries and territories, including Hong Kong and Macau (Special Administrative Regions of China) have high levels of relative risk. Of major global concern is the exposure to tsunamis of critical facilities such as airports and nuclear power plants.

Produced capital in coastal areas is also at risk from tsunamis. Tsunamis are relatively infrequent, with only 5–10 events reported globally per year, but they can be devastating, causing massive loss of life, large economic losses and the destruction of critical facilities. The Indian Ocean tsunami in 2004 is estimated to have caused about 220,000 deaths and more than US$10 billion in damages (Cosgrave, 2007). The East Japan tsunami in 2011 resulted in 15,875 deaths, 2,725 missing persons[vii] and approximately US$206 billion in damages[viii].

The global tsunami model has been updated for GAR13. Compared with the first global scale tsunami hazard and exposure assessment carried out for GAR09, the GAR13 model adopts improved methodologies and provides a more complete coverage of the global earthquake sources that might produce destructive tsunamis. This improved the model in many locations, such as Japan and Latin America.[ix] As Box 3.2 at the end of this chapter shows, the results from national

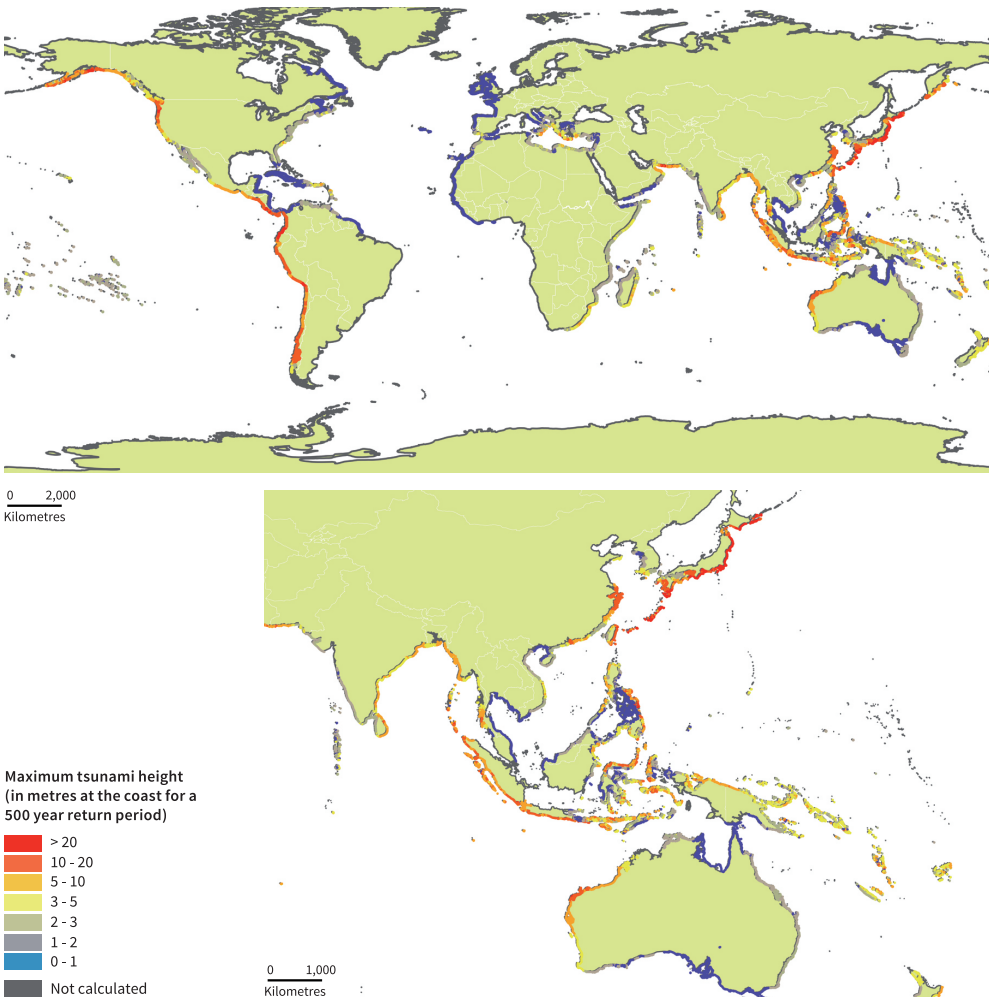
models of some countries, such as Indonesia, also contributed to the global modelling effort.

Figure 3.12 below shows the global distribution of infrequent but severe tsunamis generated by large earthquakes with return periods of approximately 500 years, equivalent to a 0.2 percent probability of occurrence in any given year.[x]

Figure 3.13 highlights the exposure of both people and produced capital to these tsunamis. Japan is highly exposed in both relative and absolute terms, and concentrates about 16 percent of exposed global produced capital. Macao (Special Administrative Region of China) also ranks high in relative and absolute capital exposed. Many smaller countries and territories also have a high

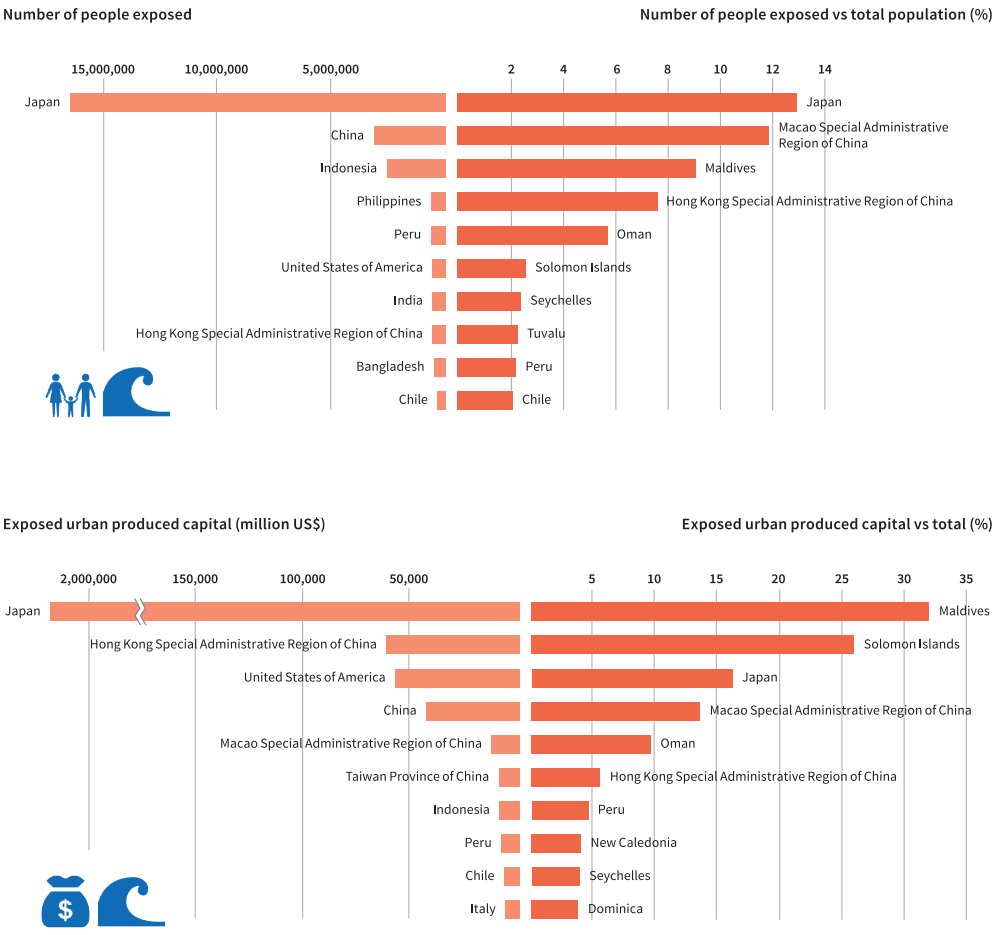
Figure 3.12 Global distribution of estimated inundation height from earthquake-generated tsunamis (500 year return period)

Tsunami hazard



(Source: UNISDR, based on NGI, 2013a)

Figure 3.13 Top ten countries in terms of population and stock of urban produced capital exposed to tsunamis (absolute and relative)[xii xiii]



(Source: GAR global risk model)

relative exposure. Maldives has over 30 percent of its produced capital stock exposed, followed by the Solomon Islands with over 25 percent; Oman with 9.5 percent; and Hong Kong (Special Administrative Region of China) with about 5 percent.

Although tsunami exposure is not the same as tsunami risk, in the case of extremely destructive 500 year return period tsunamis, exposure is probably a good guide to risk, as vulnerability tends to become binary—assets that are exposed are at risk and those that are not exposed are not.

Of particular concern is the location of critical facilities, including nuclear power plants and airports, in areas exposed to destructive tsunamis.[xi] In the United States of America, a total of 13 nuclear power plants are either in or close to areas exposed to tsunamis; in China, Japan and the United Kingdom of Great Britain and Northern Ireland, the numbers of such plants are 12, 10 and 7, respectively. However, nuclear facilities are subject to rigorous local risk assessments and thus likely to have countermeasures in place to reduce risk.

Airports are similarly at risk. In the United States of America, 58 airports are in areas exposed to destructive tsunamis; in Japan, there are 40. Airport exposure is most critical in small island states, whose economies may depend on a single airport or where all airports will be affected at the same time. In the French Polynesia archipelago, for example, a total of 26 airports are exposed.

Box 3.2 Unveiling tsunami hazard in Indonesia

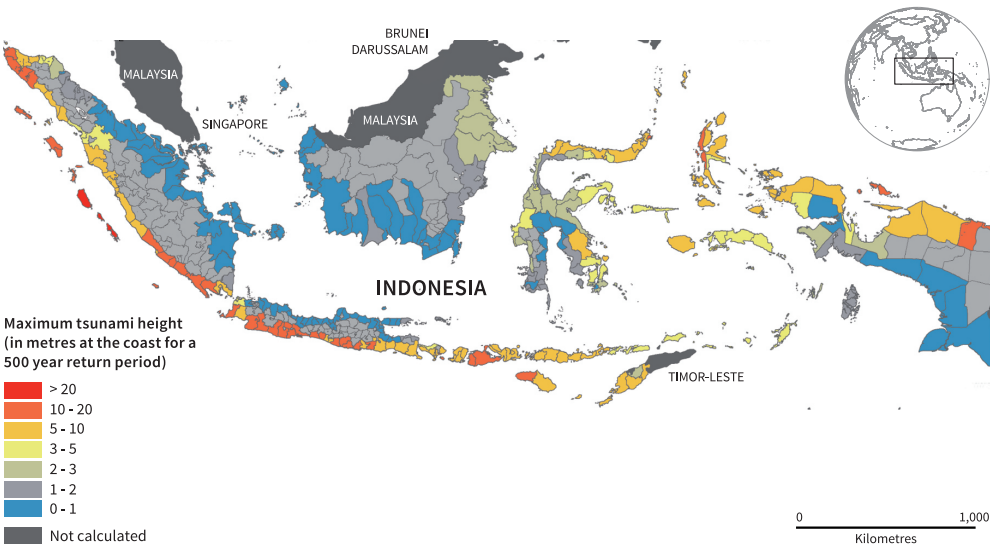
Indonesia has high tsunami risk. In the past 100 years, 24 tsunamis have killed more than 235,000 people. To better manage this risk, the national disaster management agency (Badan Nasional Penanggulangan Bencana, BNPB) and AusAID, through the Australia-Indonesia Facility for Disaster Reduction, formed a collaborative team representing Institut Teknologi Bandung, Indonesian Institute of Science (LIPI), BPPT, Badan Geologi, BMKG, TDMRC and Geoscience Australia to conduct an advanced and rigorous national tsunami hazard assessment.

Tsunami hazard maps are based on a probabilistic tsunami hazard assessment methodology, which allows the probability of tsunamis of different heights to be quantified. Maps produced allow disaster managers to:

- Understand the chance of a tsunami reaching the coastline that would trigger an orange ('tsunami') or red ('major tsunami') tsunami warning;
- Understand the maximum tsunami height over different return periods;
- Rank the tsunami potential for each district in Indonesia to prioritise communities for tsunami mitigation activities;
- Assess tsunami potential for each district to plan tsunami mitigation activities;
- Determine earthquake fault lines that may have an impact on each district.

The assessment highlights that the West coast of Sumatra, the South coast of Java and Nusa Tenggara have the highest tsunami hazard (Figure 3.11).

Figure 3.11 Tsunami hazard in Indonesia (500 year return period)



(Source: Geoscience Australia)[xiv]

Notes

i Urban produced capital is the produced capital in urban areas with more than 2,000 inhabitants.

ii Countries and territories for which no data on urban produced capital is available could not be included in the risk modelling exercise. These include: American Samoa, Andorra, Ashmore and Cartier Islands, Azores Islands, Baker Island, Bassas da India, Bird Island, Bouvet Island, British Indian Ocean Territory, Christmas Island, Clipperton Island, Cocos (Keeling) Islands, Cook Islands, Dhekelia and Akrotiri SBA, Europa Island, French Guernsey, Glorioso Island, Guam, Heard Island and McDonald Islands, Holy See, Howland Island, Isle of Man, Jarvis Island, Jersey, Johnston Atoll, Juan de Nova Island, Kingman Reef, Liancourt Rock, Madeira Islands, Midway Island, Nauru, Navassa Island, Netherlands Antilles, Niue, Norfolk Island, Northern Mariana Islands, Palmyra Atoll, Paracel Islands, Pitcairn, Romania, Saint Helena, Saint Pierre et Miquelon, Scarborough Reef, Senkaku Islands, South Georgia and the South Sandwich Islands, Southern and Antarctic Territories, Spratly Islands, Svalbard and Jan Mayen Islands, Timor-Leste, Tokelau, Tromelin Island, Wake Island, Wallis and Futuna.

iii www.unitar.org/unosat/maps/tha.

iv In countries where only a small proportion of urban produced capital is at risk, there is less chance of business and supply chain interruption and a greater likelihood of rapid recovery. In contrast, where a significant proportion of the urban produced capital is at risk, it is more likely that business will be interrupted owing to infrastructure damage and supply chain disruption and that recovery of the economy as a whole will be slower.

v Exposure is here estimated overlapping the urban produced capital with the cyclonic wind hazard for a return period of 250 years, with wind speed higher than 50 Km/h.

vi Capital exposed to cyclonic wind speed higher than 150 km/h for 250 year return period. This is a proxy for the exposure as it does not take into account flooding owing to tropical cyclones.

vii Data are as of 5 Dec. 2012 by National Police Agency, Japanese Government (http://www.npa.go.jp/archive/keibi/biki/higaijokyo.pdf).

viii 1USD=JPY81.84. The estimate was reported in June 2011 by Cabinet Office, Japanese Government (http://www.bousai.go.jp/oshirase/h23/110624-1kisya.pdf).

ix See Annex 1 for more detail on the methodology.

x The return period attributed for the model needs to be considered as an estimate, and some events might have a slightly lower or higher return period than 500 years.

xi All data related to nuclear power plants and airports at risk from Norwegian Geological Institute and UNEP-GRID.

xii In this graph, (urban) produced capital is used as a reference point for relative risk (rather than gross fixed capital formation) as the total exposure of produced capital needs to be compared with the total stock of produced capital.

xiii 'Exposure' here is calculated by overlapping the potential area inundated by an extreme tsunami (return period approximately 500 years) with the population or stock in the area.

xiv Information for this box provided directly to UNISDR by GeoScience Australia.