THE GENEVA ASSOCIATION

Insuring Flood Risk in Asia's High-Growth Markets

A GENEVA ASSOCIATION RESEARCH REPORT

by Kai-Uwe Schanz and Shaun Wang

July 2015

The Geneva Association

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and

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FOREWORD

In Asia, the insurance protection gap is yawning particularly widely. Less than 10 per cent of natural catastrophe losses in the region are covered by insurance, compared with more than 50 per cent in the U.S. Disaster coverage remains rudimentary even though Asia is heavily prone to natural catastrophes and accounts for the world's biggest share of economic losses from disasters. In addition, the region exhibits the world's fastest pace of asset and wealth accumulation, profound socio-economic changes (such as the rapid rise of megacities) and a particular exposure to climate risk, especially rising sea-levels. Therefore, the growing protection gap exposes businesses and individuals alike to devastating losses which ultimately could adversely impact Asia's future economic and societal development. There is a clear need for bold and determined responses from both the public and private sectors.

Against this backdrop, The Geneva Association is publishing this report, focusing on flooding, arguably Asia's biggest and most complex exposure in the long run. The study addresses the following key questions:

1. What is the regional and global relevance of underinsured flood risks in Asia's high-growth markets?
2. What are the specific root causes of the Asian flood insurance protection gap?
3. What can insurers and governments do to close the gap, be it through traditional or innovative means?

In light of abundantly available global insurance capacity, an accelerating pace of product innovation and a greater willingness of insurers and governments to collaborate, there is a real opportunity to effectively address the Asian flood insurance protection gap, alongside other major underinsured exposures. Through this publication and its regular work on related topics, The Geneva Association hopes to encourage decision-makers to seize this opportunity.

This report is the second in a series on global protection gaps and follows *The Global Insurance Protection Gap* (November 2014) which presents an overall assessment of the current state of global underinsurance in both the fields of non-life and life and pensions insurance.

I would like to thank our Board members Ms. Inga Beale, CEO, Lloyd's of London, and Mr. Michel Liès, CEO, Swiss Re, for co-chairing the global protection gap workstream of The Geneva Association, and for having made or facilitated significant intellectual contributions to this and other publications on the subject.

My thanks also go to our special advisor Dr Kai-Uwe Schanz and former Deputy Secretary General Prof. Shaun Wang for editing the report.

Anna Maria D'Hulster
Secretary General and Managing Director
The Geneva Association

MANAGEMENT SUMMARY

Emerging Asia is the world's epicentre of economic growth, socio-economic change (e.g. urbanisation) and expected exposure to climate change (e.g. rising sea levels). These dynamics are particularly pronounced in major coastal and deltaic urban agglomerations.

Against this backdrop, the region's exposure to flood risk is poised to increase rapidly over the coming decades. According to a recent Climate Central study,[1] by the end of the century, 147 to 216 million people are projected to live on land that will be below sea level or regular flood levels—assuming that emissions of heat-trapping gases contribute to increased levels of flood exposure and continue on their current trend. By far the largest group of 41 to 63 million exposed people will live in China.

Based on a study,[2] which includes authors from the World Bank and the Organisation for Economic Co-operation and Development (OECD), average annual economic losses from Asian flood disasters could surge to USD 500 billion or more by 2050 if no additional investments in adaptation are made, compared with average annual *global* flood losses of about USD 30 billion between 2004 and 2013, according to Swiss Re's catastrophe database. This projection also incorporates socio-economic consequences, sea level rise and subsidence. Even if massive additional adaptation investments maintain flood probability at current levels, flood-induced average annual economic losses in Asia could reach about USD 30 billion by 2050. One-hundred-year asset exposure levels in Guangzhou and Mumbai could climb to more than USD 700 billion and USD 500 billion, up from USD 39 billion and USD 23 billion, respectively. Current levels of insurance protection are grossly insufficient with, for example, more than 90 per cent of a 100-year storm surge-induced economic loss in the Pearl River Delta remaining uninsured.

Most experts agree that floods are more difficult to insure than other natural perils. There are three different forms of flood: river floods, flash floods and storm surges. River floods are the result of copious and extended rainfall or snowmelt affecting a large area whose soil's retention capacity is finally depleted. Flash floods can happen practically anywhere; these floods are produced by intense, generally short duration rainfall. Storm surges occur along coastal lines or the shores of large lakes. They are triggered by wind, which makes them a meteorological rather than hydrological phenomenon.

Therefore, flood risk is a multifaceted phenomenon, affected by very dynamic

1 Climate Central (2014).
2 Nicholls *et al*. (2008).

GIVEN THE GLUT OF GLOBAL INSURANCE CAPITAL AND THE RISE OF ALTERNATIVE RISK TRANSFER MARKETS, IT SHOULD ONLY BE A MATTER OF TIME BEFORE SOLUTIONS TAILORED TO ASIAN FLOOD RISK WILL BE ON OFFER.

changes to exposure and vulnerability and subject to limits to insurability such as a lack of assessibility and mutuality, i.e. difficulties in building a sufficiently large risk community. The latter can be addressed through compulsory insurance schemes (with risk-based premiums in order to minimise market distortions) or bundled multi-peril forms of insurance coverage, for example.

Insurance-based innovative solutions, involving international (re)insurers and capital markets as well as local governments, should also be explored, in particular if local insurance markets are not (yet) in a position to offer adequate cover to businesses and households. Given the glut of global insurance capital and the rise of alternative risk transfer markets, it should only be a matter of time before solutions tailored to Asian flood risk will be on offer—even though flood risk presents significantly bigger modelling challenges than earthquake or typhoon risk, for instance.

WHY FLOOD RISK MATTERS TO ASIA AND THE WORLD

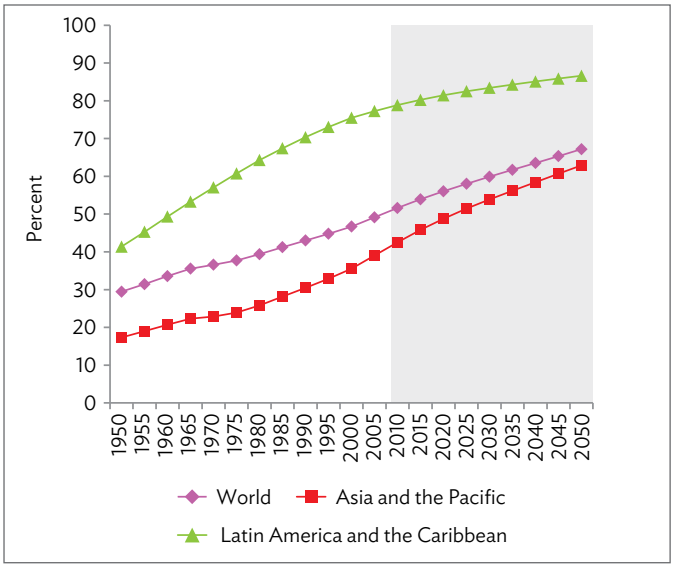
Shifting economic and insurance market balance of power

The global economic weight of emerging Asia (excl. Japan, Hong Kong, Singapore, South Korea, Taiwan and Oceania) has increased rapidly since the beginning of the 21st century, from 6 per cent of the world's GDP to 22 per cent in 2013. In line with these economic dynamics, emerging Asia's non-life premiums have expanded from 3 per cent of the world's total to 10 per cent (about USD 200 billion) in 2013. By 2025, these Asian markets are projected to account for 20 per cent of global non-life premiums.[3]

Socio-economic dynamics: urbanisation

Emerging Asia's economic rise has translated into a massive increase in asset values and their concentration. The pace of urbanisation in these high-growth markets was the world's fastest since the beginning of the century. In 2010, the region had close to 900 urban areas with more than 100,000 people, with China accounting for two-thirds of these.[4] If the region's new urban population from 2000 to 2010 were a country, it would be the world's sixth largest (with more than 200 million inhabitants). Despite this dramatic pace of urbanisation, much more is bound to come. Only 36 per cent of Asians are living in urban areas, which is below the global average and the average of other emerging regions such as Latin America (see Figure 1).

Figure 1: Level of urbanisation 1950–2050 (in % of people living in urban areas)



Source: Asian Development Bank (ADB) and Inter-American Development Bank (IDB) (2014), p. 1.

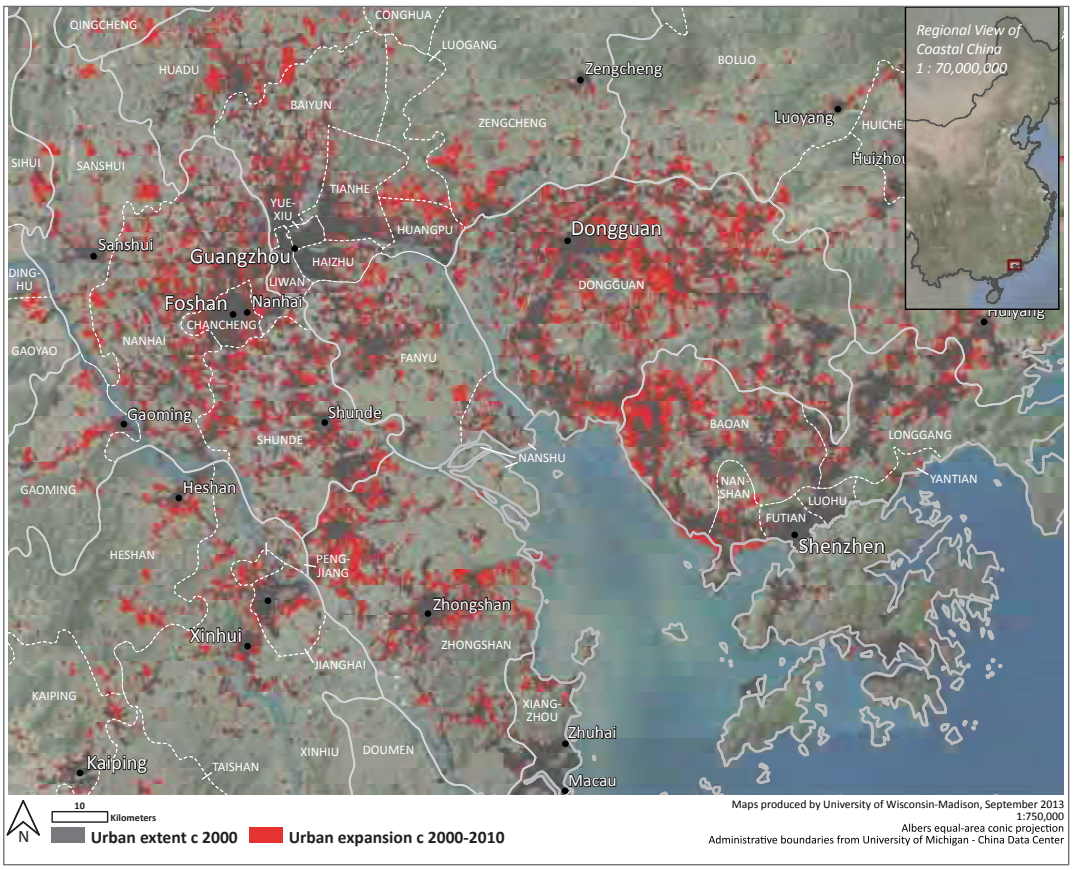
As of 2010, Asia counted 12 of the world's 22 megacities with populations exceeding 10 million. The Asian Development Bank and Inter-American Development Bank (2014) expect the number of Asian megacities to rise considerably by 2025, to 20 (including, for example, Bangkok and Jakarta).

3 Projections from Swiss Re Economic Research & Consulting.
4 World Bank (2015).

IN ADDITION TO RAPID ECONOMIC GROWTH AND ACCELERATING URBANISATION CLIMATE CHANGE ADDS TO THE SEVERITY OF ASIA'S FLOOD RISK EXPOSURE.

Almost all of these megacities are exposed to storm surge and/or river flooding. Figure 2 illustrates the dynamics of urbanisation in a particularly exposed area, the Pearl River Delta, over a relatively short period of time of 10 years. Accelerating urbanisation is compounding vulnerability as impervious surface area increases and because the topography is usually flat and drainage capacities remain insufficient.

Figure 2: Urban expansion in the Pearl River Delta, 2000–2010



Source: World Bank (2015), p. 76.

Climate risk exacerbates Asia's flood exposure

In addition to rapid economic growth and accelerating urbanisation climate change adds to the severity of Asia's flood risk exposure. People in coastal regions of Asia, particularly those living in cities, could face some of the worst effects of global warming such as flooding and rising sea levels, according to the

Intergovernmental Panel on Climate Change (IPCC).[5] People living in developing or emerging countries in low altitudes are likely to be hit hardest. Climate change in Asia, according to the report, also slows down economic growth and erodes food security.

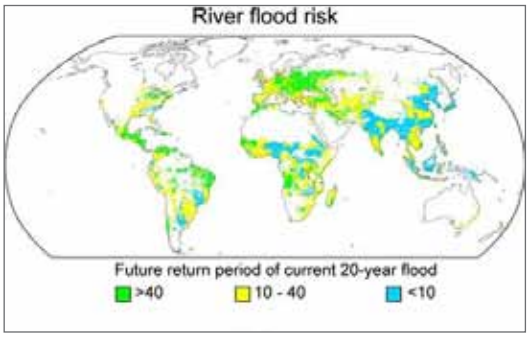
More specifically, a robust result, consistent across climate model projections, is that higher precipitation extremes in warmer climates are very likely to occur. This directly affects the risk of flash flooding and urban flooding.[6]

In this context, Geneva Association research[7] presents robust evidence that the global oceans have been warming over recent decades. And whilst many think of the atmosphere when considering the effects of climate change, it is the oceans that are the key driver of global extreme events. The warming of the oceans implies that the use of historical data and methodologies for climate risk assessments is increasingly failing.

Warmer oceans mean more water in the atmosphere; a warmer atmosphere carries more water and therefore more energy. This augments the potential for an increased intensity of extreme events and associated precipitation. Moreover, ocean warming contributes to rising sea levels, and greater volumes of ocean water present greater flood risks. Not only do rising sea levels increase the risk of flooding or the potential impact of storm surges, but they also decrease the protective lifespan of coastal infrastructure.

HIGHER PRECIPITATION EXTREMES IN WARMER CLIMATES ARE VERY LIKELY TO OCCUR. THIS DIRECTLY AFFECTS THE RISK OF FLASH FLOODING AND URBAN FLOODING.

Figure 3: Future return periods of a current 20-year flood



Source: Arnell et al. *(2014, p. 7)*

Figure 3 shows the projected future return periods of floods in different regions of the world. Intensities of river floods are projected to decrease (green colour) in

5 IPCC (2014).
6 Parry *et al.* (2007).
7 Niehörster *et al.* (2011).

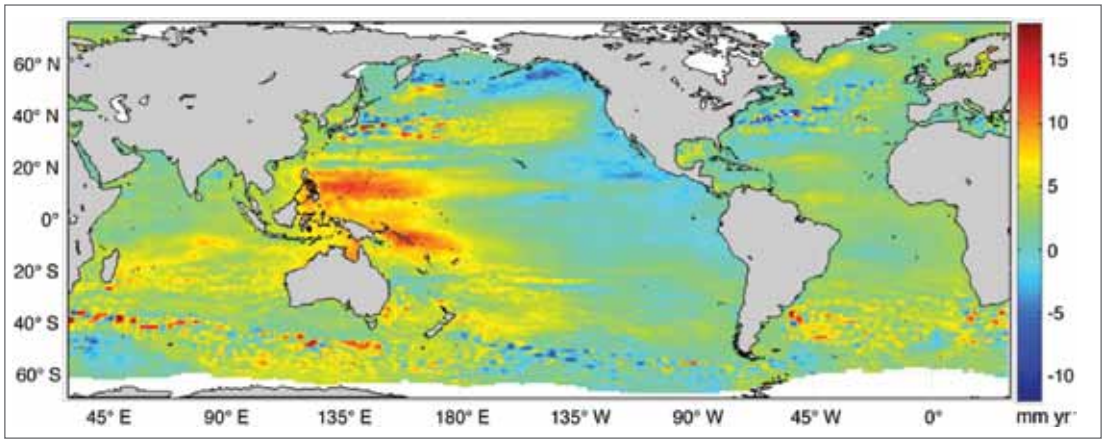
RIVER FLOOD INTENSITIES ARE EXPECTED TO INCREASE IN MOST PARTS OF ASIA.

some parts of Eastern Europe, Central America, South America and small, isolated parts in Africa. However, river flood intensities are expected to increase (blue colour) in most parts of Asia.

As far as sea level rise is concerned, there is substantial scientific uncertainty associated with it. It is certain though that the rate of global mean sea level rise has accelerated over the last 100 years.

Global mean sea level is projected to increase by 18 to 59 cm by the end of the 21st century, but confidence in these projections is low. It is also important to note that local sea level changes can be substantially different from global mean sea level projections (see Figure 4).[8] For example, from 1993 to 2010, South East Asia has experienced a rise in sea level (red colour) while the west coast of North America has seen a fall in sea level (blue colour).

Figure 4: Global mean sea level rise between 1993 and 2010



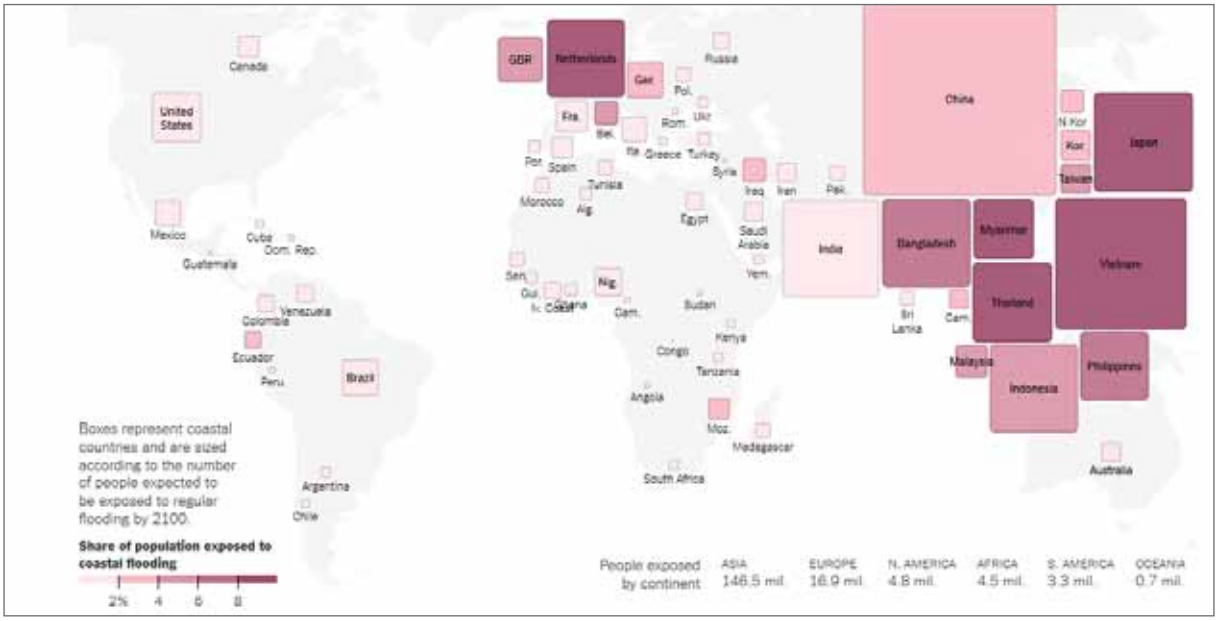
Source: Keener et al. *(2012).*

Figure 5 also serves to illustrate Asia's disproportionately high exposure to coastal flooding. By the end of the century, 147 to 216 million people are projected to live on land that will be below sea level or regular flood levels—assuming that emissions of heat-trapping gases add to flood exposure and continue on their current trend. By far the largest group of 41 to 63 million exposed people will live in China. The ranges depend on the ultimate sensitivity of sea level to warming.[9]

8 Climate Service Center (2013).
9 Aisch *et al.* (2014) and Climate Central (2014).

FLOOD RISK IN ASIA HAS NOT ONLY A MASSIVE REGIONAL BUT ALSO AN INCREASINGLY IMPORTANT GLOBAL DIMENSION.

Figure 5: Share of population exposed to coastal flooding by 2100



Source: Aisch et al. *(2014), based on a Climate Central study.*

Global ramifications of Asia flood risk

Flood risk in Asia has not only a massive regional but also an increasingly important global dimension. The Thai floods in 2011 are the most powerful example. Due to the country's outsized role in global manufacturing, the impact of the disaster was not limited to Thailand. The country's 2011 floods actually reduced global industrial production by 2.5 per cent. While the floods impacted a number of industries, electronics manufacturers and auto companies were particularly hard hit: Western Digital, producer of one-third of the world's hard disks, lost 45 per cent of its shipments, while Toyota lost 240,000 cars.

For the global (re)insurance industry the floods rank among the 10 costliest disasters ever, with insured losses amounting to more than USD 16 billion, more than a third of economic losses—and, by any other regional standards, a remarkably high level of flood coverage as a result of the massive proportion of foreign-owned assets insured.[10]

10 Haraguchi and Lall (2014).

GAUGING EXPOSURES

This report cannot offer sophisticated quantitative analyses of economic and insured losses arising from Asia's biggest flood scenarios. This information is proprietary to risk carriers, brokers and modelling firms.

Having said this, the following chapters offer a few publicly available, relevant facts and figures as well as some own calculations which help gauge current and future economic and insured loss scenarios.

The 2011 Thai floods as an eye-opener

A very illustrative example of current levels of exposure is the 2011 Thai flood disaster. Total economic losses of USD 43 billion were equivalent to 12 per cent of the country's GDP. The flooded areas generated 40 per cent of national GDP. In other words, the GDP loss in the directly affected areas equals 30 per cent. This illustrates the potential for dramatic economic disruptions following major flood disasters, especially in globally connected commercial power regions such as the Chao Phraya river plain in Thailand. At USD 16 billion, i.e. 37 per cent of the total losses, insured losses were exceptionally high, due to the fact that 90 per cent of these losses occurred in commercial lines and 35 per cent of insured losses were related to (contingent) business interruption, driven by significant levels of foreign direct investments and global supply chain disruption.[11]

The Thai floods have served as an eye-opener as to the increasing flood exposure in emerging markets owing to growing populations and assets, the changing climate and subsidence. The disaster has also raised interest in efforts to quantify present and future flood losses such as Hallegatte *et al.* (2013). Their analysis covers the world's 136 largest coastal cities. Using a new database of urban protection and different assumptions on adaptation, the study takes into account existing and future flood defences. It offers estimated average global flood losses in 2005 and projections for 2050 which incorporate assumptions concerning socio-economic change (based on OECD projections),[12] climate change and subsidence as well as adaptation investments (which are assumed to keep flood probability constant). The analysis identifies the cities that seem most vulnerable to these trends, i.e. where the largest increase in losses can be expected.

Left: Thai people on a motor powered boat going past submerged buses in flood waters on a road in Pathum Thani, near Bangkok, Thailand in October 2011.

11 Munich Re (2013), pp. 114ff.
12 Nicholls *et al.* (2008), p. 53.

With the current defences, Asia's average annual flood losses could grow to USD 500 billion by 2050

Globally, average annual flood losses between 2004 and 2013 amounted to about USD 30 billion[13] and are projected to increase to USD 52 billion by 2050 with projected socio-economic change alone.[14] With climate change and subsidence, and based on *current* levels of protective measures, annual losses would surge to USD 1 trillion or more per year, with about USD 500 billion accounted for by today's high-growth markets in Asia.[15] Even if massive additional adaptation investments maintain flood probability at current levels, subsidence and sea level rise will increase global flood losses to USD 60–63 billion and Asian flood lossesto USD 30 billion.

The estimation of economic average annual losses (AAL) is a core element of the study and a standard metric in disaster risk management planning. It explicitly takes into consideration infrastructure-based adaptation (e.g. dykes) and the vulnerability of populations and assets.

Table 1 ranks the most exposed Asian cities in 2005 and the 100-year flood exposure as a percentage of the city's 2005 GDP. It also shows the relative vulnerability, namely the ratio of AAL to the city's gross domestic product (GDP). This is the long-term average portion of the city's economic output that will be affected annually by flood risks. However, these risks are likely to be felt very unevenly. A country with a very large economy may opt for absorbing such costs over time, whereas a smaller one may prefer to take out insurance to provide instant recovery. Decades of development can be wiped out in a single event; disaster insurance provides the funds to reboot the economy straight away. Governments in larger economies may still prefer to consider the insurance approach so that large-scale disasters do not affect their other plans, particularly as the term in office for policymakers is generally finite.

DECADES OF DEVELOPMENT CAN BE WIPED OUT IN A SINGLE EVENT; DISASTER INSURANCE PROVIDES THE FUNDS TO REBOOT THE ECONOMY STRAIGHT AWAY.

Flood-exposed assets in hotspots can reach more than 100 per cent of local GDP

In relative terms, Guangzhou exhibits the largest vulnerability, with AAL reaching 1.32 per cent of local GDP. Ho Chi Minh City is most exposed to a 100-year flood event, with 133 per cent of the city's GDP at stake.

13 Swiss Re, various *sigma* studies.
14 Nicholls *et al*. (2008), p. 54.
15 Own estimate based on Nicholls *et al* (2008), p. 21 and Figure 8 in this report.

HO CHI MINH CITY IS MOST EXPOSED TO A 100-YEAR FLOOD EVENT, WITH 133 PER CENT OF THE CITY'S GDP AT STAKE.

Table 2 presents the Asian cities with the highest projected loss in 2050 assuming socio-economic change, subsidence, sea level rise and adaptation investments to keep flood disaster probability levels constant.

Table 1: City ranking 2005

Urban agglomeration	100-year flood exposure (in USD million) in 2005	100-year flood exposure as % of 2005 city GDP*	2005 AAL (in USD million)	AAL as % of 2005 city GDP
Guangzhou	38,508	76	667	1.32
Mumbai	23,188	38	284	0.47
Nagoya	77,988	78	260	0.26
Shenzen	11,388	26	169	0.38
Osaka/Kobe	149,935	37	120	0.03
Tianjin	11,408	26	104	0.24
Ho Chi Minh City	18,708	133	104	0.74
Kolkata	14,769	31	99	0.21
Jakarta	4,256	8	73	0.14

** own calculations*
Source: Hallegatte et al. *(2013), p. 2.*

Table 2: City ranking 2050

Urban agglomeration	Average annual economic loss (in USD million)	AAL as % of city GDP	100-year exposure 2050* (in USD billion)
Guangzhou	13,200	1.46	760
Mumbai	6,414	0.49	522
Kolkata	3,350	0.26	495
Shenzen	3,136	0.40	218
Tianjin	2,276	0.30	249
Ho Chi Minh City	1,953	0.83	350
Jakarta	1,750	0.22	269

**own calculations (based on the assumption that the Exposure-to-GDP ratio develops proportionally to the AAL-to-GDP ratio).*
Source: Hallegatte et al. *(2013), p. 2;*

Even with massive investments in defences AALs and exposures will surge

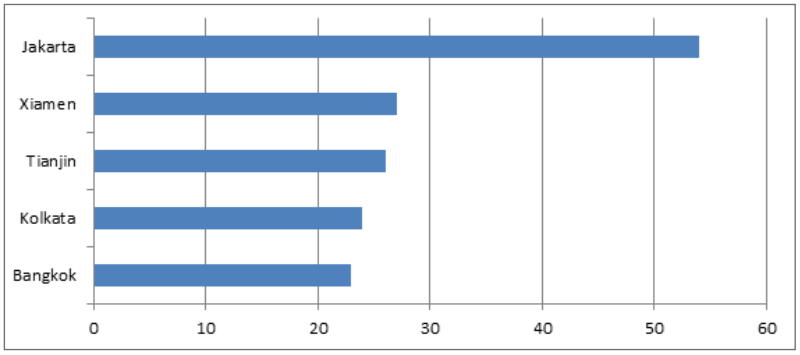
Guangzhou remains the most vulnerable city even though its AAL-to-GDP ratio is projected to increase only marginally from 1.32 per cent to 1.46 per cent.

EVEN IF THE PROBABILITY OF COASTAL FLOODING IS UNCHANGED THANKS TO UPGRADED COASTAL DEFENCE INFRASTRUCTURE, ANNUAL LOSSES WILL RISE RELATIVE TO LOCAL GDP.

During the same period of time, average annual economic losses affecting the city are forecast to increase nearly twentyfold, even if adaptation measures prove successful in keeping disaster probabilities at current levels.

Jakarta's relative flood exposure to grow fastest

Figure 6: Increase in AAL as a share of city GDP, 2050 versus 2005, in percent



Source: Hallegatte et al. *(2013), p. 3.*

The limitations of infrastructure-based adaptation

Figure 6 demonstrates that, even if the probability of coastal flooding is unchanged thanks to upgraded coastal defence infrastructure, annual losses will rise relative to local GDP. For instance, sea level rise and subsidence increase the AAL-to-GDP ratio by 54 per cent in Jakarta even if better defences maintain present flood probabilities. Each flood has the potential of being more destructive as a result of sea level rise and subsidence, offsetting the beneficial effects from better defences. This result points to the limitations of what infrastructure-based adaptation can accomplish and calls for additional measures such as improved disaster planning, including early warning and evacuation systems and more comprehensive insurance schemes and other forms of post-disaster response. In addition, experience shows that protection levels and the underlying investments are strongly influenced by cultural, political and historical peculiarities. Previous defence projects such as the Thames Barrier and the Dutch Delta Project had lead times of 30 years or more. This inertia suggests that action must begin today to protect port cities and to manage flood risk for impacts expected by the middle of this century.[16]

16 Nicholls *et al.* (2008), p. 42.

EXPERIENCE SHOWS THAT PROTECTION LEVELS AND THE UNDERLYING INVESTMENTS ARE STRONGLY INFLUENCED BY CULTURAL, POLITICAL AND HISTORICAL PECULIARITIES.

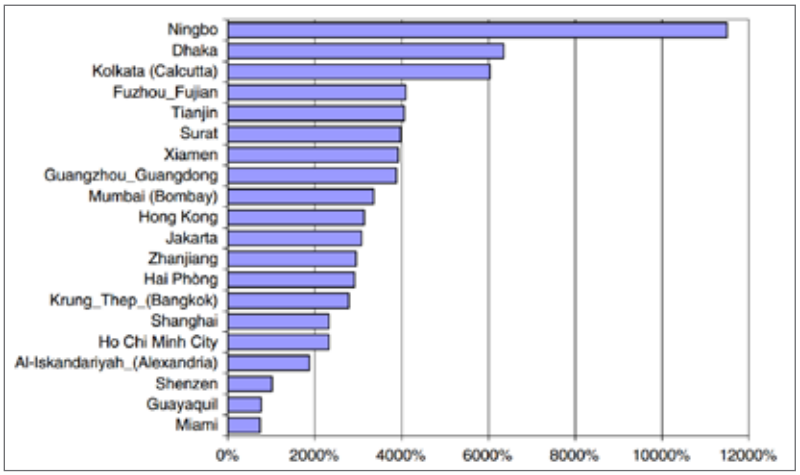
Nicholls *et al.* (2008) quantify the future exposure of major cities to surge-induced 100-year flood events *assuming no defences whatsoever*. The time horizon of the projections extends to the 2070s. The research analyses the same 136 cities as Hallegatte *et al.* (2013), 38 per cent of which are found in Asia and many of them (27 per cent) are located in deltaic settings, again, mainly in Asia. Cities in deltaic locations tend to exhibit higher coastal flood risk due to their location at lower elevations and significant (natural and anthropogenic) subsidence.

Nicholls *et al* (2008) estimate the total value of global assets (economic assets such as buildings, transport infrastructure, utility infrastructure and other long-lived assets) exposed in 2005 at USD 3 trillion or around 5 per cent of global GDP in 2005. According to the study, the total asset exposure could grow exponentially to USD 35 trillion by the 2070s or close to 10 per cent of the world's projected GDP by then, incorporating expected effects of socio-economic change, climate change and subsidence.

Future global flood exposure concentrated in Asia

By the 2070s, nine out of the top ten cities in terms of population exposure are in developing Asia: Kolkata, Mumbai, Dhaka, Guangzhou, Ho Chi Minh City, Shanghai, Bangkok, Rangoon and Hai Phòng. The top 10 cities in terms of assets exposed feature eight cities in Asia: Guangzhou, Kolkata, Shanghai,[17] Mumbai, Tianjin, Tokyo, Hong Kong, and Bangkok.

Figure 7: Increase in asset exposure 2070s versus 2005



Source: Nicholls et al. *(2008), p. 27.*

17 Shanghai has relatively advanced protection levels, similar to London, and therefore, does not feature in the exposure table presented by Hallegatte *et al*. (2013), who explicitly take into consideration current and future defences.

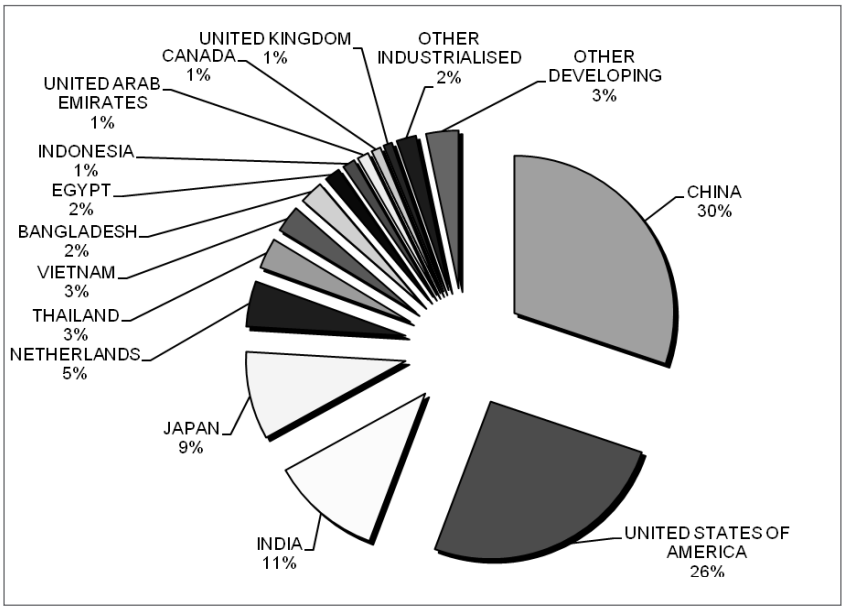
FIFTY PER CENT OF ALL GLOBAL ASSETS EXPOSED ARE PROJECTED TO BE IN ASIAN COUNTRIES WHICH TODAY ARE CONSIDERED DEVELOPING AND EMERGING.

Figure 7 lists the cities with the highest increase in exposed assets by the 2070s (compared with 2005), assuming no defences whatsoever. In some regions, the value of assets at risk of flood is expected to vastly increase causing city GDP to be highly exposed to natural catastrophe risk and potentially volatile as a consequence.

Asia projected to account for 50 per cent of all global assets exposed to flood risk

Figure 8 provides the breakdown by country of estimated asset exposure to sea level rise, storm surge and subsidence by the 2070s. Fifty per cent of all global assets exposed are projected to be in Asian countries which today are considered developing and emerging, namely China, India, Thailand, Vietnam, Bangladesh and Indonesia.

Figure 8: Assets exposed to sea level rise, storm surge and subsidence by country (total estimated exposure is USD 35 trillion) in the 2070s by country



Source: Nicholls et al. *(2008), p. 21.*

LESS THAN 10 PER CENT OF TOTAL ECONOMIC LOSSES ARISING FROM A 100-YEAR STORM SURGE DEVASTATING THE PEARL RIVER DELTA REGION WOULD BE INSURED.

Box 1: Gauging the protection gap—Pearl River Delta

In 2013, the GDP of the Pearl River Delta Economic Zone amounted to around USD 900 billion. Based on Table 1, the region's 100-year aggregate storm surge exposure could reach about 50 per cent of GDP, which translates into exposed assets of around USD 450 billion.

Swiss Re estimates the Pearl River insured storm surge MPL at USD 35 billion.* In other words, less than 10 per cent of total economic losses arising from a 100-year storm surge devastating the Pearl River Delta region would be insured.

City skyline and reflection in Guangzhou , beautiful Pearl River new town at daytime.

*Swiss Re (2013).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WHY FLOODS ARE MORE DIFFICULT TO INSURE THAN OTHER NATURAL PERILS

Floods as a multifaceted natural peril

There is a broad consensus that floods are more difficult to insure than other natural perils. There are three different forms of flood: river floods, flash floods and storm surges. River floods (or basin-wide floods) are the result of copious and extended rainfall or snowmelt affecting a large area whose soil's retention capacity is finally depleted. Flash floods (or off-plain floods) can happen practically anywhere; these floods are produced by intense, generally short-duration rainfall, and they often affect a small or even very small area in conjunction with thunderstorms. Tropical storms can trigger flash floods in larger areas, too.

Storm surges occur along coastal lines or the shores of large lakes. They are triggered by wind, which makes them a meteorological rather than hydrological phenomenon. They carry devastatingly high loss potentials and have caused hundreds of thousands of fatalities, for example in Bangladesh and Myanmar.

The risk characteristics of these three types of flood vary significantly, which is one of the reasons why this natural peril presents major challenges to insurability. The loss exposure associated with floods depends on local geographic features and thus requires very detailed risk-assessment procedures. In addition, there are large variations in vulnerability of contents, building structure and exposure by floor level in high-rise buildings.

A closer look at the components of risk helps understand these issues: risk is generally defined as the product of hazard and its consequences.[18] The consequences are determined by values at risk and vulnerability.[19]

Hazard describes the natural event and its probability of occurrence, the values at risk are the assets concentrated at the respective location, and vulnerability is a function of the location's resilience against damaging forces emanating from the event. It can come in the form of human, physical and financial vulnerability.

Flood risk is a dynamic phenomenon, given the permanent change of its components. The hazard varies with climate change, which may lead to drier or wetter conditions, more extreme flood events, rising sea levels and a higher intensity and frequency of storms.

Dynamic development of exposure and vulnerability

An even bigger driver of change is the accelerating concentration of assets in flood-prone areas.[20] This is particularly true for megacities on coasts and in flood

18 IPCC (2012).
19 Munich Re (2013), p. 240.
20 Kron (2014), p. 14.

Left: people and vehicles caught in the flooded streets after intense rain storms, Kunming China, 19 July 2013.

plains in high-growth countries such as China, Indonesia and Vietnam.

Finally, vulnerability is increasing even despite growing damage prevention efforts. One reason is the higher vulnerability of modern (electronic) equipment and building materials.[21]

Limits to insurability

All these characteristics make it challenging to assess flood risk such as the expected severity and frequency of events and the total value of insured assets in an exposed area. As such, flood risk defies assessibility, one of the fundamental principles of insurability.[22] However, state-of-the-art flood models, more elaborate field inspections and catastrophe scenario-planning based on probabilistic flood risk assessment models and supported by modern climate research have recently eased underwriters' concerns about assessibility. Technological advancements since the beginning of the 21st century have enabled breakthroughs in flood risk modelling. Google Earth™ and satellite data are examples. They have tremendously facilitated the underwriting of large risks.[23] Having said this, 'black swan'-type events such as the devastating Thai floods in 2011 still need to be reckoned with.

Besides assessibility, another challenge to the commercial viability of flood insurance is an inherent lack of mutuality. It is almost impossible to build a sufficiently large risk community including members that are not located in the most exposed areas. In the context of flood insurance, adverse selection is almost unavoidable as those who live in exposed areas are bound to seek more insurance coverage than others. If a portfolio of risks is too small for mutuality to work, the commercial viability of insurance is at risk as premiums are likely to reach prohibitive levels. In the context of flooding, the share of buildings that are seriously and frequently threatened is usually very small, at around 5 per cent of a country's real estate stock. This makes it very difficult to offer coverage on terms which are economically viable for both insurers and insureds.[24] Ultimately, the market may fail as insurers decide not to offer cover at all. However, the global reinsurance industry creates a vast pool of mutuality by offsetting, for example, earthquake risks in Japan with hurricane risks in the U.S.; hence the search for regional mutual groups can be efficiently complemented and enhanced by the use of reinsurance.

IN THE CONTEXT OF FLOOD INSURANCE, ADVERSE SELECTION IS ALMOST UNAVOIDABLE AS THOSE WHO LIVE IN EXPOSED AREAS ARE BOUND TO SEEK MORE INSURANCE COVERAGE THAN OTHERS.

21 Kron (2014), p. 14.
22 See Berliner (1985) for a fundamental analysis of large risks and limits of insurability and Knutti and Bresch (2013), p. 47, for an overview.
23 Swiss Re (2012).
24 *Ibid.*

INSURING FLOOD RISKS IS FRAUGHT WITH DIFFICULTIES, ALSO IN COMPARISON WITH OTHER NATURAL PERILS.

To complicate matters further, the insurability of flood risk is subject to constant change. For example, whilst more sophisticated modelling techniques have improved the assessibility of flood risk, they have weakened another key prerequisite to insurability: the randomness of flood occurrences. In addition, mutuality patterns can change. Supposedly safe areas can still be inundated because of extreme rainfall, but also as a result of more and more surface areas being built on, with adverse effects on natural drainage.[25] Last but not least, flood risk is heavily influenced by human actions such as the establishment of water reservoirs, water control structures and flood protection measures. Even during an event, outcomes can be affected by actions such as the deliberate flooding of retention areas.

The bottom line is that insuring flood risks is fraught with difficulties, also in comparison with other natural perils. In order to make flood exposure insurable there is a strong need for innovative solutions, public–private partnerships and government intervention, as discussed in more depth in the following chapter of this report.

25 Swiss Re (2012).


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HOW TO ADDRESS FLOOD RISK IN ASIA

TRADITIONAL INSURANCE PRODUCTS

In many developing countries of Asia, most private insurance companies do not provide flood insurance. Even in mature markets such as Australia, the extent of coverage available is very limited and often considered only as a supplement and subsumed in policies for special industrial risks.

In a developing markets environment the cost of flood insurance could also be prohibitively high due to the private insurance industry's limited capacity, low operational efficiency, insufficient risk information and limited access to reinsurance markets.[26]

More relevant are the fundamental challenges to insuring flood risk, as discussed in the previous chapter of this report. Given its catastrophic nature, flood risk is difficult to gauge, in particular if structural flood protection measures are insufficient and complex socio-economic dynamics (e.g. rapid urbanisation) are at work.

Coping with an endemic lack of mutualisation

A lack of mutualisation and economic viability present the two biggest single challenges to building an effective private-sector flood insurance system. An example:

> "An owner of a building located in a 20-year flood zone, which in the event of flooding would suffer a 20% loss, would have to pay an unaffordable annual premium of more than 1% of the total insured value. For example, for a house that is valued at USD 200 000 the insured would have to pay an annual premium of over USD 2 000. This is a premium rate that is not economically sensible."[27]

In this example, the USD 2,000 is the risk-based premium; risk-based pricing should be an integral part of any insurance-based approach to disaster risk mitigation in order to incentivise adaptation measures.[28] However, when risk-oriented premiums are not affordable to the majority of the population, this affordability gap would reduce the pool of insureds, running counter to the fundamental principle of insurance. In this case, there is a role for government agencies to bridge the affordability gap and promote mutualisation (pooling of risks) by subsidising flood insurance premiums in conjunction with incentives for and investments in prevention measures to reduce the likelihood and severity of potential losses.

26 Tun *et al.* (2007), p. 20.
27 Swiss Re (2012), p. 15.
28 The Geneva Association (2009).

Left: Chinese armed police soldiers flood fighting on 4 August 2012, Luannan, Hebei, China.

MUTUALISATION OFTEN LEADS TO 'MAL-ADAPTATION' AS THE AVAILABILITY OF SUBSIDISED INSURANCE MAY RESULT IN A LACK OF RISK PREVENTION AND ENCOURAGES BUILDING ACTIVITIES IN FLOOD-PRONE AREAS.

Building a sufficiently large risk community whilst encouraging adaptation

This being the case, it is of paramount importance to build a sufficiently large risk community, if necessary supported by compulsory (fire and allied perils) insurance requirements in order to ensure that adequate premium volumes are generated, mutuality works and individual rates are affordable. If this is the case, capacity should be sufficient to also cover losses from extreme flooding. At the same time, when introducing such systems, lawmakers and regulators need to keep in mind the need to minimise moral hazard and adverse selection. This can be achieved, for example, through risk-based pricing and deductibles. Insurers must be given the leeway to apply such measures in order to ensure that compulsory schemes do not introduce distortions into insurance markets.[29]

This is particularly important with new risks. In this respect, mutualisation often leads to 'mal-adaptation' as the availability of subsidised insurance may result in a lack of risk prevention and encourages building activities in flood-prone areas.

An alternative is for the private sector to offer insurance policies which cover a wide spectrum of different natural perils, including flood, hail, wind and earthquake in order to diversify the risk presented by high-risk flood communities. Such a package could be made even more affordable by combining it with fire coverage.

The average premium rate for a sufficiently broad risk community can be as low as 5 per cent of the level required for a smaller community restricted to high exposure risks. Insurability would further improve on the back of additional risk-based differentiation of rates and the introduction of policyholder deductibles. In general, in order to limit cross-subsidies from low-risk areas to high-risk areas, structural measures such as building levees and dykes must be taken.[30]

Harnessing diversification to improve capital efficiency and affordability of insurance

We have identified a lack of mutualisation (and thus the affordability gap) as a major cause of underinsurance (or the protection gap) in emerging Asian economies whose populations have relatively low incomes as compared to advanced economies.

As a main pillar of insurance, diversification through pooling can reduce the total capital requirements for insuring catastrophe risks and thus lower the

29 Schanz and Wang (2014), p. 53.
30 See the Appendix for an overview of established flood insurance schemes in developed countries.

Box 2: An illustrative example of quantifying the diversification benefit in terms of a reduction in required capital

We assume that capital requirements for insuring catastrophe risks are determined by the 100-year maximum possible loss (or the 99.5th percentile of the loss exceedance curve). We further assume that catastrophe risks are mutually independent, with each having an Exponential(α) distribution with a mean value of α =USD 10 billion.

As a well-known mathematical property, the sum of n mutually independent Exponential(α) random variables is an Erlang(α, *n*) random variable. It is noted that the Erlang(α, n) distribution is a special case of the family of gamma distributions. This mathematical property enables closed-formula derivation of the 99.5th percentile of the aggregate loss distribution, Erlang(α, *n*).

The table below shows a numerical example of pooling catastrophe risks from three separate regions, each having an Exponential(α) distribution with a mean value of α =USD 10 billion. One can derive that the 99.5th percentiles of each of the Exponential(10) distributions is USD 52.98 billion, thus the sum of required capital for separately insuring three regions is USD 158.94 billion. The global pool of three regions has an aggregate loss distribution of Erlang(10, 3), whose 99.5th percentiles is USD 92.74 billion. Therefore, the required capital for the global pool of three regions is USD 92.74 billion, which represents a 42% reduction in the total required capital of USD 158.94 if each of the three regions is insured separately.

	Region 1	Region 2	Region 3	Sum of three separate regions
Required capital	USD 52.98	USD 52.98	USD 52.98	USD 158.94

	Global pool	Sum of three regions	Reduction in required capital
Required capital	USD 92.74	USD 158.94	42%

Further diversification benefits can be realized through multiple region-perils diversification. As shown in the below numerical example of pooling risks from five separate region perils, the reduction in required capital can be up to 52%.

	Region-Peril 1	Region-Peril 2	Region-Peril 3	Region-Peril 4	Region-Peril 5	Sum of five separate region-perils
Required capital	USD 52.98	USD 52.98	USD 52.98	USD 52.98	USD 52.98	USD 264.90

	Global pool for five region perils	Sum of five separate region perils	Reduction in required capital
Required capital	USD 125.94	USD 264.90	52%

THERE ARE VARIOUS WAYS OF DIVERSIFYING CATASTROPHE RISKS, INCLUDING GEOGRAPHIC DIVERSIFICATION, MULTI-PERIL DIVERSIFICATION, AND MULTI-YEAR DIVERSIFICATION.

cost of insurance. There are various ways of diversifying catastrophe risks, including geographic diversification, multi-peril diversification, and multi-year diversification. In reality, optimal levels of diversification have not been achieved due to various regulatory restraints that limit the scope for diversification. For instance, capital requirements for branches of global (re)insurers are set at local jurisdiction level, without explicit recognition of geographic diversification or the fungibility of capital. The resultant fragmentation of insurers' capital base makes insurance more expensive.

To tap into the full potential of diversification, insurers could consider the following ideas:

1. Establish a global catastrophe capital reserve which is owned by global (re)insurance companies.
2. Set up an independent statistical agency to compile global catastrophe loss indices by the following aggregates:
    a. multi-regions of the same peril: total losses from flood in various regions and countries such as the U.S, Canada, Germany, U.K., China, Australia, etc.;
    b. multi-perils: total losses from wind, earthquake and flood;
    c. multi-years: accumulation of losses over time.
3. Introduce an innovative catastrophe insurance product with a two-tier limit:
    The first tier has a fixed basic limit paying out immediately without haircut or delay.
    The second tier has a flexible limit which may be subject to a haircut according to one of the reported global catastrophe loss indices. The flexibility of the second-tier limit should alleviate the need for the global insurance industry to provide 'spike' cushion capital for each individual jurisdiction. This flexibility recognises geographic diversification benefits, provides capital relief to reinsurers and lowers the cost of insurance for consumers.

In sum, by tapping into the full potential of diversification, insurers can lower the cost of insurance, which in turn will likely help increase the insurance take-up of the populations in emerging Asian economies (thus enlarging the insurance pool as well as lowering the administrative expenses per insurance policy). Against this backdrop, it is very regrettable to see an increasing trend in a number of Asian jurisdictions towards barriers to the cross-border provision of (re)insurance services, e.g. through minimum levels of reinsurance to be placed locally, additional capital requirements for foreign reinsurance branches and special credit risk charges applied in respect of foreign reinsurers. These restrictions are set to

reduce the benefits of cost-efficient global diversification of risk, making insurance more expensive for domestic policyholders. In addition, any attempts to increase the national retention of risk may turn out costly in the event of a major disaster, which could result in a severe strain of the balance of payments due to the loss of exports and the higher cost of imports following such an event. Even an annual net outflow of foreign exchange in a liberal cross-border reinsurance trading environment is no reason per se to restrict transactions—it may be a reasonable price to pay for security, as for individual and corporate policyholders alike.

Implications for government policies and insurance regulation

The business model of insurance is based on risk pooling and diversification. Government policies and regulation should therefore recognize that:

- allowing cross-border reinsurance transactions is essential to reaping the benefits of geographic diversification.
- allowing insurance capital to be fungible (mobile) across jurisdictions will benefit consumers in all countries.

Insurance regulation is still fast evolving. Whereas regulations in the Western world focus on tighter solvency regulations and more rigorous capital requirements, emerging economies look at the role of insurance more in light of facilitating economic development. Striking a balance between these two views is essential. After all, good regulation is meant to not just ensure solvency, but also improve capital efficiency, ultimately facilitating healthy competitive insurance markets which will benefit consumers. In order to achieve the goal of more balanced regulations, a joint effort is required comprising the industry and its capital providers, consumer groups (both retail and wholesale), governments and regulators.

ALLOWING CROSS-BORDER REINSURANCE TRANSACTIONS IS ESSENTIAL TO REAPING THE BENEFITS OF GEOGRAPHIC DIVERSIFICATION.

Capturing the insurance industry's full potential in identifying and assessing disaster risk[31]

The insurance industry's contribution to managing flood risk extends well beyond the losses it pays out. Insurers help individuals, companies, governments and communities reduce disaster risk through research, modelling and analytical work. These efforts produce tangible results such as business continuity plans, supply chain management procedures, hazard maps, etc.

Insurers' expertise looks both back by leveraging aggregated data from past events

31 United Nations Environment Programme Finance Initiative (2014).

FLOOD INSURANCE IS GREATLY SIMPLIFIED IN TERMS OF RISK-BASED PRICING IF IT IS APPLIED ON A FLOOR LEVEL BASIS RATHER THAN WHOLE BUILDING BASIS.

and forward by modelling future exposure. If based on a thorough analysis and assessment of the underlying exposure, the level of insurance premiums provides a reliable indication of existing risks and loss probabilities. This helps stakeholders make a comparison of the risk/return profiles of projects, thereby ensuring that the available resources are put to the best possible use.

Insurance companies also offer consultancy services, advising on how to improve safety standards and a product's quality, for example. These services are based on extensive financial and non-financial knowledge: a fire insurer needs to know about building codes and materials, a flood insurer about geographic features and meteorological conditions, a health insurer about medicine and pharmacology, etc.

The insurance risk management process mirrors the continuum of activities in disaster risk management: from understanding, assessing, preventing and reducing disaster risk—to measures of response and relief, recovery and risk financing. Therefore, the insurance industry is actively involved in all relevant areas of disaster risk management: natural hazards (e.g. floods), biological hazards (e.g. epidemics) and technological hazards (e.g. industrial pollution and transportation accidents).

Against this backdrop we recommend that governments and inter-governmental agencies make it mandatory for major new development projects to first undergo a quantitative assessment of exposure to natural hazards (including flood risks and potentially rising sea levels), before funds or loans are committed by commercial banks, regional and international development banks. The insurance industry stands ready.

Unique features of residential flood risk in Asia

For many Asian countries, the main type of buildings in urban areas is high-rise. The proportion of single-family houses in urban areas is relatively small and tends to decrease. Therefore, most residential units in high-level floors are not subject to flooding risk. As pointed out by Walker *et al.*,[32] flood insurance is greatly simplified in terms of risk-based pricing if it is applied on a floor level basis rather than whole building basis. This approach also helps adaptation by discouraging high values in lower floors and encouraging the use of flood resistant materials.

The affordability gap is a major challenge in Asia. It can be measured by the ratio of annual income over the expected loss (expected frequency times expected severity of loss). In major urban areas of emerging Asia, the average income-

32 Walker *et al*. (2009).

THE THAI FLOODS IN 2011 HAVE DEMONSTRATED THE SCALE OF THE SURPRISE A MAJOR FLOOD DISASTER STRIKING A BOOMING COMMERCIAL AND INDUSTRIAL REGION IN ASIA CAN GENERATE.

to-property value ratio is much lower than in developed countries. This creates a special challenge to property insurance (including flood insurance).

Table 3: Affordability of residential flood cover: an illustrative example

Frequency	Probability	Amount at risk (USD)	Insured value (USD)	Expected loss (USD)	Able & willing to pay (USD)	Subsidy needed
1 in 100 yrs	0.01	100,000	20,000	200	120	40 %
1 in 50 yrs	0.02	100,000	20,000	400	120	70 %
1 in 20 yrs	0.05	100,000	20,000	1,000	120	88 %

Spiralling commercial flood exposures

In the past 20 years, Asia has witnessed a rush for urbanisation and economic development, and many factories have been built along coasts, especially in river deltas. However, most construction activities were carried out without long-term historical data on floods and storms and without considering the threat of future rising sea levels, increasing rainfall and more intense storms.

The Thai floods in 2011 have demonstrated the scale of the surprise a major flood disaster striking a booming commercial and industrial region in Asia can generate. Most of the damage was to the manufacturing industry, as seven major industrial estates were inundated by as much as three metres during the floods.[33]

Many insurance experts agree that an even bigger loss is likely to occur in China, the engine of global manufacturing, where large areas of factory estates are vulnerable to flooding and storms. The Pearl River Delta is one of China's biggest industrial zones. The western side of the delta, constructed on sediment-filled fish ponds and rice paddies, is flat for up to 100 km inland, and 40 percent is less than 2 meters above sea level.[34]

There are also dense concentrations of factories in other parts of Asia, particularly in and around the Indonesian capital Jakarta, a manufacturing hub for U.S., European and Japanese firms. In Cikarang, east of Jakarta, five industrial estates with more than 3,000 plants employ over 1 million people.

The low-lying coastal city has 13 rivers flowing through it, is subsiding in parts and faces rising sea levels. The Jakarta area was hit by floods in 2005 and 2007 and, with increasing exposure due to newly built industrial parks in the region, it is not hard to expect large flood losses for the region.

33 Also see Chapters "Gauging exposures" and "Why floods are more difficult to insure than other natural perils".

34 See "Why floods are more difficult to insure than other natural perils" for an exposure estimate relating to the Pearl River Delta.

ASIA IS CHARACTERISED BY RAPID ECONOMIC DEVELOPMENT AND URBANISATION. THEREFORE, IT IS CRITICAL TO DIFFERENTIATE BETWEEN EXISTING AND NEW RISKS.

Differentiating between existing and new risks

As shown earlier in this report, Asia is characterised by rapid economic development and urbanisation. Therefore, it is critical to differentiate between existing and new risks. For the former (where the infrastructure is already in harm's way), insurance solutions need to be found. On the other hand, for new construction projects, extensive risk exposure assessment is of paramount importance, and perhaps should even be mandated by the funding agencies. Simply avoiding high values in the low-lying sections of properties can avoid material losses. For example, new constructions can start residential occupancy from the first or second floors. Low floors can be built out of flood resistant materials; regional development can 'make space for water', enabling sustainable urban drainage. This is an area where the insurance industry can contribute its risk assessment expertise.

Domestic insurers facing significant loss exposure

In a number of Asian insurance markets (including China), flood insurance is typically sold as part of a general property policy and does not have an upper claims limit. Rapid development and high levels of mean foreign investment have multiplied the amounts insurers have at stake when the next major flood disaster strikes. Fierce competition among domestic insurers and competition from abroad frequently translate into low premium rates (from a technical point of view). In combination with a lack of long-term disaster risk assessment, this means that insurance companies are potentially exposed to severe losses.

INSURANCE-BASED INNOVATIVE SOLUTIONS

The promise of alternative capital

Given the glut of capital as a result of post-financial crisis monetary policies, a growing number of industry experts and executives suggest that capital markets-based innovative insurance solutions can and should play a larger role in tackling uninsured and underinsured risks, in particular as the new capital entering the (re)insurance market through insurance-linked securities (ILS) and collateralised reinsurance is believed to be a lasting phenomenon. For example, reinsurers could grow their line sizes using third-party capital (with lower return expectations), allowing them to more effectively target new and underinsured risks or regions, potentially even using parametric covers rather than indemnity-based solutions.

As the nature and complexity of natural catastrophes have changed in recent decades, alternative products to supplement traditional insurance and generate

additional capacity from the capital markets have been developed as early as 20 years ago. Some of these products also allow for a swift infusion of funds following an event and are particularly suitable when little or no information on exposure is available, such as the location, value and nature of the risks to be insured. Trigger-based solutions are very effective under such circumstances, as the payout is based on the mere occurrence of the event rather than on any specific insured losses incurred.[35] These solutions benefit from the availability of quantitative models and exposure data.

Mitigating basis risk

The fundamental flaw of trigger solutions is basis risk, i.e. the inevitable gap between modelled/estimated and actual losses. More specifically, this could imply that the insured does not receive any payment in spite of suffering severe financial losses.[36]

However, when designed appropriately,[37] trigger products are an important alternative for risks that cannot be insured traditionally, for example, due to limited exposure information. Meaningful applications for Asian countries are scarce, with so far only Japanese earthquake and typhoon and Taiwan earthquake risk having been transferred to capital markets via catastrophe bonds. For many developing and emerging countries, there are only a few professional risk models in general and for flood risk in particular.[38]

In addition, there are flood-specific challenges associated with parametric solutions due to the complexity of the peril. A parameter used to measure rainfall, for example, might not be suitable to cover other types of flood like a river flood. In addition, precipitation might occur far away from the area that will actually be inundated.[39]

WHEN DESIGNED APPROPRIATELY, TRIGGER PRODUCTS ARE AN IMPORTANT ALTERNATIVE FOR RISKS THAT CANNOT BE INSURED TRADITIONALLY.

Instant relief through parametric insurance

But parametric solutions offer great advantages which can offset the challenges presented by basis risk: as they do not require lengthy loss adjustment procedures, payouts can be made promptly and provide instant relief. This is of particular importance in developing countries where insurance is especially important

35 Munich Re (2013), pp. 372ff.
36 Cummings and Weiss (2009), p. 497.
37 Basis risk can be reduced effectively, for example, in the case of parametric flood solutions, through flood footprints based on modern remote sensing technology (Swiss Re, 2012, p. 21).
38 Munich Re (2013), p. 375.
39 Swiss Re (2012), p. 21.

GOVERNMENTS IN EMERGING ASIA ARE INCREASINGLY AWARE OF THE NEED FOR PROFESSIONAL DISASTER RISK MANAGEMENT.

because uninsured losses trap vulnerable populations in a vicious cycle of destitution. Unfortunately, agricultural insurance and disaster insurance are either unavailable or prohibitively expensive in many developing countries. Hence, a number of global insurers and reinsurers have become involved in promoting the use of parametric solutions in some of these countries (see Box 3).

Box 3: AXA Corporate Solutions' partnership with the World Bank Group's Global Index Insurance Facility (GIIF) *

In February 2015, Axa Corporate Solutions signed a new partnership with the International Finance Corporation (IFC)-World Bank in order to develop parametric insurance in Africa, Asia, and Latin America, with a focus on maintaining food security after natural catastrophes.

Axa will collaborate with the World Bank's Global Index Insurance Facility (GIIF), a multi-donor trust fund supporting the development and growth of local markets for weather and disaster index-based insurance in developing countries. To date, GIIF's implementing partners have covered more than 600,000 farmers, pastoralists and micro-entrepreneurs with USD 119 million in sums insured. GIIF's objective is to expand the use of index insurance as a risk management tool in agriculture, food security and disaster risk reduction.

The objective is to develop products which provide for quick compensation and benefit from low claims administration costs. Payment is triggered if a specific threshold for flood, drought and other weather-related disasters is reached. There is no need for experts on the spot, and payment of compensation is automatic. The insurance scheme draws on advancements in the space industry and the processing of data which allow for much more precise meteorological data used as a trigger.

* *http://www.artemis.bm/blog/2015/02/16/axa-to-work-on-parametric-weather-insurance-with-world-bank/*

PUBLIC–PRIVATE PARTNERSHIPS

Governments in emerging Asia are increasingly aware of the need for professional disaster risk management (DRM). Strong economic growth in conjunction with rapid urbanisation and industrialisation and manifold climate-related hazards translate into exponentially increasing risk exposures, as outlined earlier in this report. Annual average losses could reach crippling dimensions unless comprehensive mitigation and adaptation measures are taken. By 2050, assuming current defences, emerging Asia alone may see annual flood-related economic losses of USD 500 billion.[40]

DRM is based on the traditional risk management cycle which includes risk identification, analysis, planning, implementation and review. The planning stage needs to involve all available mitigation options such as risk avoidance, reduction, prevention, transfer and retention.[41]

40 Own estimate based on Nicholls *et al.* (2008), p. 21 and Figure 9 in this report.
41 Knutti and Bresch (2013), p. 6.

COLLABORATION BETWEEN THE PUBLIC AND PRIVATE SECTOR CAN PROVE CRUCIAL IN DEVELOPING INSURANCE MARKETS FOR PREVIOUSLY INADEQUATELY INSURED OR UNINSURED EXPOSURES.

Given spiralling levels of exposure, Asian governments seek more timely relief and reconstruction by tapping into additional resources and leveraging the concept of DRM and risk transfer and retention in particular through national disaster risk-financing and insurance schemes.[42]

Boxes 4 and 5 describe two prominent schemes in Thailand and Indonesia, respectively. The two examples differ in terms of insured risks, their overarching political objectives and the degree of government involvement. They demonstrate that collaboration between the public and private sector can prove crucial in developing insurance markets for previously inadequately insured or uninsured exposures, regardless of whether the risk insured is a geophysical risk or a weather risk.

Box 4: The Thai National Catastrophe Insurance Fund*

The Thai government set up the National Catastrophe Insurance Fund (NCIF) after the disastrous flood events of 2011. The main purpose of the Fund is to provide additional reinsurance capacity at subsidised rates in order to enable heavily battered domestic insurers to continue offering coverage against natural disaster risks at affordable rates, not only to households and SMEs but also to the (partially foreign-owned) industrial sector.

Under the NCIF, domestic insurers can cede a part of their disaster risk (flood, windstorm and earthquake) to the Fund.

The Fund insures values of around USD 16 billion despite the fact that disaster risk insurance and domestic insurers' participation in the Fund is not compulsory.**

* Munich Re (2013), p. 295.

** Thongphakdi (2014), p. 3.

Box 5: MAIPARK (Indonesia)*

MAIPARK was set up by the Indonesian government in 2003 in order to address self-destructively fierce levels of competition among domestic non-life insurance companies in providing earthquake insurance covers. Following the deregulation of the insurance sector in the late 1980s, an increasing number of insurers started to offer earthquake insurance without charging risk-commensurate premiums, raising concerns that, in case of a major disaster, the insurance industry might not be able to meet its obligations to policyholders.

In response, the government of Indonesia required all primary insurance companies to pool their respective earthquake liabilities in an Indonesian Earthquake Reinsurance Pool. In 2004, the pool was transferred to a special-purpose company, Asuransi MAIPARK Indonesia.

It is worth noting that MAIPARK's mission statement also includes the goal of contributing to an integrated disaster risk management approach and to the development of a national and regional database of catastrophe risks.

* Munich Re (2013), pp. 300f.

42 Munich Re (2013), p. 299.

THE INSURANCE INDUSTRY NEEDS TO PROVIDE FLOOD RISK EDUCATION AND WORK TOWARDS A POSITIVE IMAGE IN THE LOCAL COMMUNITY TO INCREASE THE TAKE-UP WILLINGNESS IF FLOOD INSURANCE IS PROVIDED.

Box 6: Japan Earthquake Reinsurance Co., Ltd (JER)*

Residential earthquake insurance in Japan is provided jointly by the public and private sectors. Major earthquakes can result in massive insurance payouts. As a precaution against such events, both private-sector insurers and the government share the potential insurance liabilities through reinsurance. All earthquake insurance policies directly underwritten by non-life insurance companies are ceded to JER, who homogenises the risk exposure and partially retrocedes it back to the participating non-life insurance companies and the government up to predefined liability limits for each.

* For more information on the Japanese Earthquake Insurance Company, see the article on the Tohuku earthquake and tsunami by Masaaki Nagamura in The Geneva Association (2013), page 47.

Box 7: Lessons from agricultural insurance in China

China is the world's second largest agricultural producer, and drought and flood alone account for 80 per cent of nation-wide crop damage. Government-sponsored agricultural insurance for natural disasters has been available in China since 2007.* However, it is limited to crops and livestock and does not cover farmers' real estate or household property. Therefore, post-disaster government assistance remains the main source of relief in China. Insurance is still of marginal importance, with only 1–2 per cent of flood losses insured and flood insurance for real estate and associated properties simply not available in rural China.**

The underlying challenge, however, is not limited to the supply side. Low demand and the perceived unaffordability are of similar importance. Ren *et al.* (2014) performed an extensive field study on the willingness to pay for flood insurance in rural China. They show that people's annual income is a major determinant of insurance buying decisions, which is consistent with Kousky and Kunreuther (2013), who found that the participation rate and coverage levels of the U.S. National Flood Insurance Program (NFIP) increase with income.

Ren *et al.* (2014) present the following key findings in relation to insurance solutions and government policies towards flood insurance:

- Flood risk exposure, economic development and social characteristics in different areas should be taken into consideration in formulating flood insurance programme.
- Government subsidies are likely needed for flood insurance in rural areas, similar to the government subsidised agricultural crop insurance programme. The Chinese government should have good reasons to provide such subsidies, as they help increase budget predictability by transferring the risk of disaster relief expenditure to the insurance industry.
- The insurance industry needs to provide flood risk education and work towards a positive image in the local community to increase the take-up willingness if flood insurance is provided.
- Both flood insurance coverage and premiums should be maintained at moderate levels considering income levels and government subsidies. Low premium/low coverage policies, similar to the crop insurance program in China, should be considered.

* See Schanz and Wang (2014), p. 44, for what is widely regarded the most successful PPP in emerging Asia.
** Guy Carpenter (2010).

THE MOST FUNDAMENTAL SPLIT OF RESPONSIBILITIES BETWEEN THE PUBLIC AND PRIVATE SECTOR IS FOR THE FORMER TO FOCUS ON SETTING A CONDUCIVE LEGAL FRAMEWORK AND FOR THE LATTER TO DEVELOP APPROPRIATE RISK TRANSFER SOLUTIONS AND TO ABSORB AND MANAGE THOSE RISKS MOST EFFICIENTLY.

Box 8: Pacific Catastrophe Risk Insurance Pool Pilot

Launched in January 2013, the pilot helps reduce the financial vulnerability of small Pacific island nations to natural disasters. This regional sovereign insurance pool is made possible through the collective efforts of the Government of Japan, the World Bank, the Global Facility for Disaster Reduction and Recovery and the Secretariat of the Pacific Community (SPC). It is comprised of five members—the Cook Islands, Marshall Islands, Samoa, Tonga and Vanuatu.

Vanuatu has recently received USD 1.9 million after the risk-pooling facility was triggered by Category 5 Cyclone Pam, which hit the island nation on 13 March 2015. The payment was made within three weeks post-event, demonstrating the important role that parametric triggers play in effecting rapid insurance payouts. The payout might have been even quicker with a pure parametric trigger, but the Pacific risk pool pursues a modelled loss approach to the calculation of loss.

This payment is the second time the Pacific Catastrophe Risk Insurance Pilot has been triggered since it was launched in January 2013. Tonga was the first country to benefit from a payout in January 2014 after Cyclone Ian.*

The World Bank acts as an intermediary between the scheme and a group of reinsurance companies, which were selected through a competitive bidding process.

The most fundamental split of responsibilities between the public and private sector is for the former to focus on setting a conducive legal framework and for the latter to develop appropriate risk transfer solutions and to absorb and manage those risks most efficiently.

* *http://www.artemis.bm/blog/2015/03/30/vanuatu-paid-1-9m-for-cyclone-pam-from-pacific-catastrophe-facility/*

How governments can promote flood insurance in Asia

The spectrum of public-sector measures includes:

- implementing a risk-based solvency regime;
- providing access to international (re)insurance markets;[43]
- strengthen prevention and disaster resilience through enforcement of building codes and other regulatory specifications for strength of building foundations as well as tax incentives for preventive measures;
- introducing compulsory insurance schemes so as to create a sufficiently large 'risk community' as a prerequisite to mutuality;
- collecting exposure data and supporting risk research and modelling. And detailed and publically available flood maps as an essential first step for making flood insurance universally available;

43 Unfortunately, as mentioned on pages 30–31 of this report, there is a growing trend, including in Asia, to erect barriers to cross-border (re)insurance. Such restrictions are likely to discourage a broader take-up of flood insurance, based on an increased availability at lower cost.

STRUCTURAL MEASURES CAN ENTAIL UNWANTED EFFECTS SUCH AS MAKING FLOOD-PRONE AREAS MORE ATTRACTIVE FOR RESIDENTIAL AND COMMERCIAL USE.

- offering temporary insurance premium subsidies to encourage the development of an insurance market;[44]
- acting as insurers or reinsurers for certain risks where risk assessment is a particular challenge and where loss potentials exceed the capacities of the private sector (however, for most weather-related and other natural catastrophe risks, the private sector has the capacity—currently available at abundant levels—and expertise to absorb the risks);
- creating a link between those affected locally and the global reinsurance industry—either through the local insurance industry via reinsurance or by channelling funds from parametric products to those affected;
- buying (re)insurance in order to fund disaster expenses before a catastrophe occurs and also to pay for damages on critical infrastructure and other government property.[45]

Besides governments, supranational development banks can contribute greatly to paving the way for higher flood insurance penetration. For example, after Typhoon Haiyan, one of the most powerful typhoons ever recorded, hit the Philippines in November 2013, the Asian Development Bank (ADB) launched a broad spectrum of supportive measures. These were not only designed to help restore, repair and rebuild critical infrastructure but also to promote disaster resilience, through more appropriate building standards, for instance. In total, about USD 1 billion were committed in support of the region devastated by Haiyan. In addition, the ADB is very active in supporting disaster (including flood)-specific research aimed at facilitating insurance-based solutions.[46]

This chapter has shown that PPPs can go a long way in enabling coverage of risks that would otherwise not be insured or not sufficiently insured, burdening private households, enterprises or the governments with disproportionate exposures. Political decision-makers in Asia are increasingly aware of the need for and benefits of collaborative disaster risk financing and insurance schemes.

44 Tun *et al.* (2007), p. 22f. See also Table 3 in this report.
45 Swiss Re (2012), p. 22.
46 For more examples of insurance and government public private partnerships, see *Insurers' contributions to disaster reduction—a series of case studies* (The Geneva Association 2013).

FLOOD INSURANCE CAN BE CONSIDERED A NON-STRUCTURAL MEASURE AS IT AFFECTS THE COSTS OF LIVING AND DOING BUSINESS IN FLOOD-PRONE AREAS.

PRE-DISASTER RISK MITIGATION[47]

Structural measures as a double-edged sword

Engineering interventions are designed to keep floodwaters away from people and assets. Most, if not all, flood risks can be mitigated by such structural measures. However, the cost to be borne by governments may be prohibitive. In addition, structural measures can entail unwanted effects such as making flood-prone areas more attractive for residential and commercial use. Non-structural measures such as zoning and building codes aim to achieve the exact opposite: Keep people away from floodwaters or encourage them to live rationally amid the threat through prudent land and disaster management.

Based on the following formula, this complex decision-making problem can be addressed in a balanced and holistic way.

Risk = Hazard x Exposure x Vulnerability[48]

Hazard describes the varying intensities and probabilities of flood, exposure is the total economic values present at the location concerned, and vulnerability is the degree of damage to assets. For example, an embankment can reduce the hazard probability whilst possibly adding to the vulnerability and exposure to floods due to property development and increase in population in the affected area. Another example of conflicting effects is dams, which may reduce the hazard probability by managing peak flows and reducing the probability of water breaching. However, there is evidence that countries that have constructed more dams do not necessarily have fewer flood disasters and economic losses, as additional development encouraged by such structural measures might lead to increases in vulnerability and exposure.[49]

Therefore, structural measures need to be balanced and complemented by non-structural measures which, for example, ensure appropriate land use (including the maintenance of storage and detention capacities) in the wake of reclamation and resettlement along the main rivers.

Flood insurance provides important price signals

Flood insurance, too, can be considered such a non-structural measure as it affects the costs of living and doing business in flood-prone areas. A mandatory flood insurance scheme can potentially offset the impacts of structural flood protection measures on increased population and economic activities by adding the insurance premium back to people's costs of living and investments.

47 Tun *et al.* (2007), pp. 4-10 and Munich Re (2013), pp. 251–265.
48 Munich Re (2013), pp. 239ff.
49 Tun *et al.* (2007).

POSSIBLE CONCLUSIONS

- The current relevance of private-sector insurance and reinsurance in terms of mitigating flood risk in Asia's high-growth markets is limited, if not marginal. In 2014, only 10 per cent of economic losses from all natural disasters in Asia were insured, compared with 60 per cent in North America.[50] This is particularly alarming as, over the past few decades, the region has borne the brunt of global economic losses from natural disasters, including floods.
- In the absence of meaningful insurance cover, the cost of relief and reconstruction falls on governments, non-governmental organisations, charities and, worse, the affected households and companies. This is a particular threat to low-income countries such as Bangladesh, Myanmar and Vietnam.
- In light of rapidly growing flood-related asset exposures and their increasing share in domestic GDPs the (re)insurance industry will have to deploy major efforts just to maintain the current level of insurance penetration, let alone play a more meaningful role in absorbing economic and societal flood losses and adding more value to local governments, businesses and households.
- Addressing the challenge requires both a multi-stakeholder and a combined 'bottom-up/top-down' approach. Stated differently: private and public sector entities need to join forces to implement effective flood disaster risk management systems at the macro level (including adaptation measures, for new risks in particular, incentivised by insurance-based risk transfer solutions) whilst, at the same time, promoting insurance penetration in retail and commercial lines of business at the micro level.
- Specific measures could include:[51]
    - encouraging local insurers to develop and launch appropriate catastrophe insurance solutions: non-life insurance in emerging Asia is still highly skewed toward motor or health business, compared with commercial lines such as energy, fire, and engineering. Current fire policies which include natural disaster risk frequently have high deductibles, which partially explain their low take-up. In general, any effective and sustainable disaster risk management strategy needs to include enabling the development of local insurance markets;
    - developing a broad array of *ex ante* disaster risk financing instruments based on the severity and frequency of natural calamities, including

50 Swiss Re (2015).
51 Some of these suggestions are based on Asian Development Bank (2014) and Schanz and Wang (2014).

Left: hard to circulate situation at Ho Chi Minh city when flood tide, flooded water on street, vehicle traffic in water, danger, unsafe scene, Vietnam, 9 October 2014.

ADDRESSING THE CHALLENGE REQUIRES BOTH A MULTI-STAKEHOLDER AND A COMBINED 'BOTTOM-UP/TOP-DOWN' APPROACH.

risk transfer products such as indemnity-based insurance, reinsurance and parametric insurance, along with capital market solutions such as catastrophe bonds for the high risk layer;

- exploring the regional applicability of mature-market flood insurance schemes (bundled/optional, private/public);[52]
- structuring catastrophe bonds and other forms of insurance with parametric triggers to protect against typhoons and earthquakes as a starting point ('MultiCat Asia-Pacific'): due to a lack of models catastrophe bonds may not be feasible to protect against flood risk specifically, for the time being;
- developing and promoting a regional platform for collecting and disseminating relevant data, as a joint public–private effort: the lack of quality historical loss data as well as data on risk exposure and asset vulnerability, in combination with the high cost of (proprietary) modelling is a major obstacle to higher flood insurance penetration in emerging Asia. Governments could, for example, encourage insurance industry supported academic efforts towards open-source modelling of flood risks;
- including parametric products, microinsurance schemes and insurance-linked securities in local regulatory frameworks, offering tax incentives for private insurance coverage and considering insurance as a risk management tool for government entities;
- considering a regional risk pool for natural calamities, taking into account experience from existing schemes such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF), the Pacific Catastrophe Risk Insurance Pilot (PCRIP) and the African Risk Capacity (ARC), which were formed with technical assistance from the international development community and risk management support from international (re) insurers. However, as a note of caution, the applicability of these examples is limited given the much larger scale of exposures in China or South East Asia and the respective funding and modelling requirements; this is particularly true for flood risk, which is widespread and, therefore, more difficult to model than earthquake or typhoon risk;
- involving global reinsurance and alternative capital markets: this will be crucial to ensure that disaster risk management initiatives reach the necessary scale and capacity.

52 See "Traditional insurance products", page 27.

APPENDIX:

EXAMPLES OF DEVELOPED-WORLD FLOOD INSURANCE SCHEMES

The spectrum of prevalent insurance schemes and solutions is broad and reflects national peculiarities: some countries have a long tradition of comprehensive, compulsory flood insurance; other countries prefer optional schemes (with flood cover being independent of any other perils), whereas yet others rely on bundling flood cover with other natural (or even man-made) perils in order to create sufficiently large risk communities.

Each approach has specific pros and cons: optional flood coverage is subject to adverse selection and all the problems associated with it. By contrast, flood insurance penetration tends to be higher with a bundled system in place which allows insurers to diversify flood risk across perils and geographical areas. Those schemes are particularly effective if pricing is risk-based which, in turn, tends to require official flood hazard zoning. In addition, optional and unbundled systems can also work if detailed flood risk information is available and risk-adequate premiums are charged.

FLOOD INSURANCE PENETRATION TENDS TO BE HIGHER WITH A BUNDLED SYSTEM IN PLACE WHICH ALLOWS INSURERS TO DIVERSIFY FLOOD RISK ACROSS PERILS AND GEOGRAPHICAL AREAS.

Whether flood insurance is mandatory or not, national insurance schemes generally can be categorised into the following four categories:[53]

- Type 1: 'public and optional'
- Type 2: 'public and bundled'
- Type 3: 'private and optional'
- Type 4: 'private and bundled'.

The U.S. practises the Type 1 model (public and optional) through the National Flood Insurance Program (NFIP), a cooperation between the insurance industry and the U.S. federal government. Government officials determine prices and coverage based on pre-defined flood zones and flood risk. Private insurers sell the flood insurance policies as a government agent, i.e. they do not assume the risk. The programme is back-stopped, i.e. subsidised, by the federal government. The main flaw of the system is its inability to address the issue of adverse selection. Only mortgage-holding homeowners living in a 100-year-zone are obliged to buy government-backed flood insurance. Therefore, premiums are too high for those living on the border of such a zone.[54]

France is an example of Type 2 scheme (public and bundled). The government covers losses from flood, earthquake and a number of other natural perils. All homeowners covered against fire and theft are obliged to participate. This additional coverage comes at a uniform price across the country, determined by the government and is, therefore, not reflective of the actual risk characteristics.

53 Tun *et al.* (2007) and Swiss Re (2012).
54 Czajkowski *et al.* (2012).

Highly exposed homeowners are thus subsidised by those exposed to low risk. On the one hand, the programme has been successful in achieving high penetration. On the other hand, it does not offer any incentives to homeowners to think about and invest in risk prevention and reduction.

Germany relies on Type 3 (private and optional), under which private insurance companies offer supplementary and voluntary coverage to homeowners. All insurers use a detailed flood risk map based on which risk-adequate premiums can be determined. As opposed to standard building insurance, market penetration of supplemental hazards insurance is very low. Flood relief payments by governments to uninsured homeowners significantly reduce incentives to purchase cover.[55]

The U.K. used to operate the Type 4 model (private and bundled). Some 2.2 million or 10 per cent of the total number of homes are at risk from coastal or inland flooding.[56] As early as in 1961, a 'gentlemen's agreement' was struck between insurers and the U.K. government, loosely defining respective responsibilities. As a result a system for private natural catastrophe insurance emerged, making private and risk-based flood insurance available (and affordable) as part of standard home insurance policies. The government plays an important supporting role by, for example, guaranteeing quality flood maps, adequate flood defences and effective land use.

This system has proven successful in as much as ensuring that the vast majority of households are covered against flood damage. However, there are serious challenges: according to previous agreements, older contracts in high-risk areas must cover flood risk, usually involving an element of cross-subsidisation. On the other hand, new contracts can exclude high-risk areas. Insurers offering such contracts can offer cheaper premiums in low-risk areas and, therefore, enjoy a major competitive advantage. Older, established insurance companies, however, are burdened with severe problems of adverse selection.

The gentlemen's agreement (statement of principles) came to an end in 2013. In June of the same year the Association of British Insurers and the Government agreed on how to develop a not-for-profit scheme—Flood Re—to allow flood insurance to remain affordable and available and level the playing field for both established and new carriers. Insurers will be able to pass to government-backstopped Flood Re (at a set premium) the exposure of high risk households. At the same time, the scheme is designed to ensure a smooth transition to risk reflective pricing over the next 25 years.

55 Schwarze and Wagner (2004).
56 Swiss Re (2012).

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The rapid population and economic growth in Asia is exacerbating an already significant protection gap in the region. In this report, The Geneva Association focuses on flooding, arguably Asia's biggest and most complex exposure in the long run.

This report is the second in a series on global protection gaps and follows, *The Global Insurance Protection Gap* (November 2014) which presents an overall assessment of the current state of global underinsurance in both non-life and life and pensions insurance.

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