Natural disaster risk in Asian megacities
A case for risk pooling?

Stefan Hochrainer *, Reinhard Mechler

IASA – International Institute for Applied Systems Analysis, Schlossplatz 1, A-2361 Laxenburg, Austria

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ABSTRACT

This paper examines the characteristics of natural disaster risk in the context of megacities generally, and Asian megacities particularly. A key gap in approaches to managing megacity risk has been attention to the financial aspects, for which interest has lately been emerging in terms of exploring whether such risk may be suitable for a donor-assisted regional Asian risk pooling scheme. One suggestion concerns insuring public sector liabilities in terms of infrastructure replacement funding, liquidity support and relief to the population. Recently, this was operationalized in the Caribbean regional pooling of hurricane and earthquake risks, and by the Mexican government for earthquake risks. In both cases, central governments are the actors. We assess the rationale and applicability of such deliberations given the dynamic nature of vulnerability and risk, and discuss conditions for conducting similar transactions for Asian megacity risks. Overall, given our adopted criteria, we tentatively conclude that there may indeed be a case for risk pooling, yet the dynamics of assessing formal and informal risks as well as the specificity of conditions in respective megacities pose important hurdles that have to be overcome.

Introduction: disaster risk and megacities

The last few decades have seen the rise of increased urbanization and the birth of megacities. According to some estimates, 2006 marked the year when for the first time, more people were living in urban areas than in rural areas, and this trend is predicted to continue (UN United Nations, 2004). Megacities, which are standardly defined to house a population exceeding 10 million, are the most extreme manifestation of this trend. Currently, there are about 19 such cities, which are projected to increase to about 27 in 2025 (UN, 2008). Urban areas in Asia are among the world’s fastest growing and are expected to house 55% of the estimated 5 billion Asians by 2030. By then, the 12 Asian megacities will house 10% of the Asian population (ADB, 2008).

Disaster risk is a key threat to such dense urban spaces as evidenced by events in the recent past. The Kobe earthquake of 1995 affecting the Kobe/Osaka conurbation resulted in 6000 fatalities and more than 100 billion US$ direct economic losses. The Tanshan earthquake in China in 1976 represented one of the largest urban disasters in the 20th century. Death toll rates are reported to have been between 246,000 and 500,000 (Wenzel, Bendimerad, & Sinha, 2007). Furthermore, predicted risk to a number of megacities is high. As one example, the city of Istanbul is very likely to experience strong shaking from a large earthquake in the Marmara Sea in the next three decades (Parsons, 2004). Other megacities are exposed to tropical cyclones (various cities in Japan and China) as well as earthquakes (for example Teheran and Tokyo) or urban flooding (Mumbai). Sea-level rise and therefore climate change is another key issue for megacities: out of China’s estimated urban population of 400 million, 130 million live in coastal cities that are vulnerable to sea-level rise (World Bank & UN-ISDR, 2008). Currently, 8 out of the 10 most populous cities in the world, including Metro Manila and Jakarta have moderate to high earthquake hazard. Similarly, 8 out of 10 of the most populous cities are located on the coast and are vulnerable to storm surge and tsunami waves (ADB, 2008). Accordingly, urban and, particularly, megacity, disaster risk has risen in importance on the international agendas; megacities and disaster risk were systematically addressed already as a high priority issue during the United Nations-sponsored International Decade for Natural Disaster Reduction (1990–1999) and lately climate change policy has been increasingly focusing on the role of cities and mitigation as well as adaptation to natural disasters (World Bank & UN-ISDR, 2008).

As part of generally promoting the application of the disaster risk management paradigm (consisting of risk assessment, prevention, preparedness, risk financing as well as risk communication) to megacities’ stakeholders and decision makers, recently interest has been voiced to explore whether megacity disaster risk may be suitable for a regional risk pooling scheme, broadly similar to the Caribbean Catastrophe Insurance Facility (CCRIF), which was set up...
in 2007 and was supported by donors and International Financial Institutions. This paper assesses the larger dimensions of megacity risk financing including its rationale and prospects of developing risk financing mechanisms that can be part of a comprehensive risk management scheme for megacities in Asia and other regions.

The paper is organized as follows. Section 2 discusses challenges and opportunities of disaster risk management strategies and introduces a risk layering approach about how to structure risk management decisions. Section 3 then focuses on public-sector risk management and presents two important examples in more detail. Afterwards, Section 4 introduces the idea of pooling megacity risks and explains obstacles and possible solutions to them. Section 5 concludes with key roles for further research and policy.

### Managing disaster risk: challenges and opportunities

Disaster management covers a whole array of interventions, as shown in Table 1, comprised of ex-ante interventions (prevention, preparedness and risk financing) as well as ex-post action (relief and reconstruction). The balance today is still tilted heavily to ex-post interventions with about 95% of funds being spent here (see Mechler, 2004). Financial support after events can be organized by arranging ex-post relief after the fact or implementing insurance systems or contingent reserve funds before a disaster event materializes.

Table 1 is not exhaustive and a comprehensive risk management strategy also needs to tackle the root causes of vulnerability, which are often affected by political and economic constraints. Furthermore, modalities of disaster relief distribution are important, especially for the informal sectors and very poor communities, and it cannot always be assumed that governments and corresponding institutions respect equality in their distribution task.

### Structuring risk management decisions

Broadly speaking, disaster risk management decisions focus on reducing or financing disaster risk. Extreme event risk forms a class of its own within the risk management field because the risk is of covariate (dependent) nature compared to “everyday,” idiosyncratic (independent) risk such as potentiality of car accidents. Reasons include, (i) disasters cause enormous, exceptional losses (Munich Re, 2010; Swiss Re, 2010); (ii) informal mechanisms for coping with idiosyncratic risk fail in the case of extremes (Hochrainer, 2006); (iii) disasters are often neglected in the decision planning process due to its low probability of occurrence (Kunreuther, 1996; Slovic, 2000) and the already tightened budget constraints, especially in developing countries (Mechler, 2004), and last, but not least, (iv) loss financing capabilities and immediate help is very restricted and depends often on outside assistance which makes planning very difficult (Linnerooth-Bayer, Mechler, & Pflug, 2005). It should be stressed that for making those special schemes, discussed below, viable, donor assistance is needed (Linnerooth-Bayer et al., 2005).

As Table 1 indicates, risk management of extremes can cover a whole array of options. While building codes, dams and preparedness programs reduce risk, risk financing accepts risks, pools it and shares it over many shoulders. From a demand side perspective, risk financing may be a suitable option if agents perceive themselves to be unable to cope with the consequences of an event; this perception is usually described by the term risk aversion.

Using a layering approach, as shown in Fig. 1, for low- to medium loss events that happen frequently, prevention is likely to be more cost effective in reducing burdens than risk financing. The reason is that the costs of prevention often increase disproportionately with the severity of the consequences. Moreover, individuals and governments are generally better able to finance lower consequence events (disasters) from their own means; for instance, savings or calamity reserve funds, and including international assistance (Mechler, 2004). The opposite is generally the case for costly risk-financing instruments, including insurance, catastrophe bonds and contingent credit arrangements. Catastrophe insurance premiums fluctuate widely and are often substantially higher than the pure risk premium (average expected loss), mainly because the

### Table 1

<table>
<thead>
<tr>
<th>Type</th>
<th>Ex ante risk management</th>
<th>Risk assessment</th>
<th>Prevention</th>
<th>Preparedness</th>
<th>Risk financing</th>
<th>Ex post-disaster management</th>
<th>Response</th>
<th>Reconstruction and rehabilitating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect</td>
<td>Assessing risk</td>
<td>Reduces risk addressing underlying factors</td>
<td>Early warning systems, communication systems</td>
<td>Transfers risk (reduces variability and longer term consequences)</td>
<td>Responding to an event</td>
<td>Rebuilding and rehabilitating post event</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key options</td>
<td>Hazard assessment (frequency, magnitude and location, including climate change)</td>
<td>Reduces risk in the onset of an event</td>
<td>Alternative risk transfer</td>
<td>Risk transfer (by means of (re-)insurance) for public infrastructure and private assets, micro-insurance</td>
<td>Humanitarian assistance</td>
<td>Rehabilitation/ reconstruction of damaged critical infrastructure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vulnerability assessment (population and assets exposed)</td>
<td>Land-use planning and building codes</td>
<td>Clean-up, temporary repairs and restoration of services</td>
<td>Contingency planning, networks for emergency response</td>
<td>Rehabilitation/ reconstruction of damaged critical infrastructure</td>
<td>Revitalization for affected sectors (exports, tourism, agriculture, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Risk assessment as a function of hazard, exposure and vulnerability</td>
<td>Economic incentives for pro-active risk management</td>
<td>National and local reserve funds</td>
<td>Networks of emergency responders (local/national)</td>
<td>Damage assessment</td>
<td>Macroeconomic and budget management (stabilization, protection of social expenditures)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hazard monitoring and forecasting (GIS, mapping, and scenario building)</td>
<td>Education, training and awareness raising about risks and prevention</td>
<td>Calamity Funds (national or local level)</td>
<td>Shelter facilities and evacuation plans</td>
<td>Mobilization of recovery resources (public/multilateral insurance)</td>
<td>Incorporation of disaster mitigation components in reconstruction activities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
insurer’s cost of back-up capital and uncertainties are reflected in the premium (Froot, 2001; Hochrainer, 2006). For this reason, it may be advisable to use those instruments mainly for lower probability hazards that have debilitating consequences (catastrophes).¹ Finally, as shown in the uppermost layer of Fig. 1, most individuals and governments find it too costly to insure against very extreme risks occurring less frequently than every 500 years (Linnerooth-Bayer and Mechler, 2007).

The decision on where to best invest and manage risk is particularly relevant for Asian megacities, given the massive projected increase in built-up regions, formal and informal residential areas and infrastructure. If urban sprawl is to continue as currently projected, there is a clear need to mainstream disaster risk and aim at disaster resilience in new structures and infrastructures in order to reduce loss of life and economic assets during an event. Resilient cities will need to consider, for example, building shelters not located on marginal land in flood plains or steep slopes. It seems important to consider integrated land use and transport policies and develop clusters of high density nodes which may support mass traffic, sustainable development of residential areas, infrastructure, commercial services, and districts of business and commerce. Clearly, “returns” to risk reduction in megacities are massive and can be harnessed with a systematic and integrated approach as for example promoted by the Earthquake Megacity Initiative (EMI) and their concept of a master plan.²

**Financing public sector disaster risk**

There are many modalities for disaster-exposed agents, households, businesses and city/central governments, to use risk-financing instruments. The best known instrument is insurance, providing indemnification against losses after an event, in exchange for a premium payment before events (Kunreuther, 1998). Yet, there is a whole array of pre- and post-disaster arrangements for financing recovery, such as savings, kinship arrangements or raising tax revenue or building mutual pools. Insurance is practically non-existent in many countries and, even where it exists, the market share (of losses) is generally less than 30% (see Aakre and Rübbelke, 2010). In the absence of government assistance and international aid, poor victims rely on an array of (often innovative) pre- and post-disaster arrangements for financing their recovery. As shown in Table 2, insurance is only one of many different modalities for this purpose. The most usual financial course is to raise needed capital after a disaster strikes: individuals take out emergency loans from family, micro-credit institutions or money lenders; sell or mortgage assets and land; or rely on public and international aid (Linnerooth-Bayer et al., 2005). Likewise, governments raise post-disaster capital by diverting funds from other budgeted programs, borrowing money domestically, or taking loans from international financial institutions. While many locally based funding sources, for example, borrowing from neighbours or family, appear to work reasonably well for small localized events (Cohen & Sebstad, 2003), they are problematic for catastrophes that affect large regions or many persons at the same time (so-called co-variant or systemic risks). To hedge against co-variant risks, households may purposely locate family members outside of harms way or diversify their livelihoods. They may also arrange contingent savings or food supplies, activities that spread risks temporally. Alternatively, households/businesses and farms can purchase property or crop insurance, which spreads risk both temporally and spatially. Insurance can be provided by micro-insurance programs, which are distinguished from other types of insurance by their provision of affordable cover to low-income clients. Like individuals, city and central governments can also spread risks temporally and spatially by setting up reserve funds or regional pools and by purchasing insurance or hedging instruments (e.g., catastrophe bonds or contingent credit), respectively.

Many of these risk financing modalities are conventional; yet, some, most notably index insurance and catastrophe bonds, are rather novel and have been made possible by new developments in modeling risks and financial transactions (Varangis, Skees, & Barnett, 2002). Whereas conventional insurance is written against actual losses, index-based (parametric) insurance is written against physical or economic triggers (Hess & Syroka, 2005). Index-based insurance is against events that cause loss, not against the loss itself. For example, the major advantage of index-based insurance is the substantial decrease in transaction costs, which, particularly for developing countries, have impeded the development of insurance mechanisms. The major disadvantage is basis risk, which is the lack of correlation of the trigger with the loss incurred.

It is not well known that local, state and central governments may also use risk financing options to manage disaster risk. City governments are no exception. For example, the city of Istanbul has been thinking about using catastrophe bonds to hedge against a big event impacting their finances due to the need to provide relief and reconstruction (Erdik & Durukal, 2008). Yet, little has been done in terms of city and megacities transferring risk. Looking at the next level of government (e.g., central government) may provide useful analogies for the case under exploration in this paper. As a basis for discussing megacity risk financing, we now present two prominent examples of recent innovative ideas to handle catastrophe risk: first Mexico’s sovereign risk financing strategy for earthquakes, followed by regional risk pooling arrangements used by Caribbean states.

**The case of Mexico: ceding sovereign disaster risk to the international markets**

Mexico has been one of the first middle-income countries to transfer the high-risk layer of its post-disaster liabilities to the international capital markets. Mexico is of special interest here because the most earthquake prone areas are within the Mexico City limits which contribute a tremendous amount to GDP (more than 50%, Cardenas, Hochrainer, Mechler, Pflug, & Linnerooth-Bayer, 2007): The first consideration of pro-active loss financing instruments within the Mexican government can be traced back to the

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¹ See Hochrainer (2006) for a summary of the advantages and disadvantages of ex-ante instruments.
² see http://www.emi-megacities.org and, especially in this context, the EMI Asian city profiles on sound DRM practices http://www.pdc.org/emi/emihome.html
Mexico City earthquake in 1985. Nearly 9000 people lost their lives, and direct economic losses from this disaster were estimated at $7 billion (in 2006 $) or 2.7% of the GDP in the year of the event (CRED, 2006). Furthermore, colossal expenses on rehabilitation and reconstruction resulted in an increase in the fiscal deficit of $1.9 billion over the next 4 years. Despite inflows from private sector (business and households) insurance and foreign donations, the earthquake was estimated to have caused a negative effect of $8.6 billion in Mexico’s balance of payments over this period (Jovel, 1989). This event and its long lasting consequences sensitized the Mexican authorities to the benefits of pro-actively engaging in prevention and financial disaster risk management.

Hence, in order to be financially better prepared and improve efficiency in public-sector risk management, legislation was passed in 1994 requiring federal, state and municipal public assets to be insured. Furthermore, in 1996 the authorities created a financial risk management program (FONDEN) and began budgeting for contingent disaster spending. Subsequently, the government created a catastrophe reserve fund within FONDEN (the FONDEN trust), which accumulates the unspent disaster budget of each year.

As shown in Fig. 2, budgeted FONDEN resources have been declining over time. Moreover, demands on FONDEN’s resources are volatile, and outlays have often exceeded budgeted funds. As a consequence, the reserve fund has diminished, and finally in 2005, after the severe hurricane season affecting large parts of coastal Mexico, the fund was exhausted. The uncertainty associated with FONDEN to provide sufficient post-disaster finance led officials of the Ministry of Finance and Public Credit (hereafter referred to as the Finance Ministry) to consider hedging against natural disaster shocks.

An assessment of their financial vulnerability provided the platform from which the authorities planned their financial risk management measures. Basing their analysis on past demands and spending by FONDEN, staff at the Mexican Finance Ministry set a vulnerability threshold at roughly $500 million, above which the fund would not be able to cover post-disaster outlays. This amount was calculated as the sum of average FONDEN spending over the last years (around 4 billion Pesos or $310 million) plus one standard deviation (2400 million Pesos or about $190 million). If a disaster were to occur that required outlays beyond this sum, it is expected that FONDEN would not be able to fulfil its legal obligations for response and relief, and additional sources would be needed. Thus, FONDEN would be financially vulnerable beyond such a loss.

To transfer this layer of risk (middle layer in Fig. 1), a mix of re-insurance and a catastrophe bond (linked to a physical trigger, i.e. magnitude of the earthquake) with a total coverage of $450 million over a 3-year period (2007–2009) was undertaken by the government in 2006. The parametric transaction of public-sector risk was obviously accepted by the market and hence financial cover was provided by the cat-bond as well as re-insurance. Such transactions as the Mexico cat-bond are likely to set an important precedent throughout the world for protecting highly exposed developing and transition country governments and megacities against the financial risks of extreme catastrophes, and thus ensuring their ability to support the recovery of vulnerable citizens.

The Caribbean regional risk financing: pooling public-sector risk

Pooling extreme risk deserves special attention. If insurers with limited capital reserves choose to indemnify large co-variant risks (losses occurring at the same place/time), they must guard against insolvency by diversifying their portfolios, limiting exposure and/or transferring their risks to the global re-insurance and financial markets. Yet, due to lack of access to the re-insurance markets and the high cost, many insurers are operating with little financial backup arrangements. This is not a problem for small pilot schemes, but raises a question of viability when scaling up. Similarly, governments of developing countries, particularly those of small states, pay international prices that are subject to fluctuations caused elsewhere. For example, Barbados, which is one of few countries insuring public infrastructure, experienced a 10-fold increase in insurance premium after Hurricane Andrew in 1992 despite the fact that Barbados is not in a major hurricane path. A promising strategy to more effectively diversify risks is through intergovernmental risk pooling arrangements.

Caribbean island states in 2007 formed the world’s first multi-country catastrophe insurance pool to provide governments with immediate liquidity in the aftermath of hurricanes or earthquakes. The Caribbean Catastrophe Risk Insurance Facility (CCRF) went into operation in June 2007 with the participation of 16 Caribbean countries, whose governments contributed resources ranging from US$200,000 to US$4 million depending on the exposure of their specific country to earthquakes and hurricanes. This pool is expected to result in a substantial reduction in premium cost of about 45–50% for the participating countries. The fund covers up to 20% of the estimated infrastructure loss, and claims will be paid depending on an index for hurricanes (wind speed) and earthquakes (ground shaking). Initial funding by donor organizations provided support for start-up costs and helped capitalize the pool. The facility will transfer the risks it cannot retain to the international financial markets through re-insurance or through other financial instruments (for example, catastrophe bonds). The accumulation of reserves over time should lessen the facility’s dependence on outside risk transfer. Should the total insured losses exceed its claims-paying capacity, payouts will be pro-rated based

<table>
<thead>
<tr>
<th>Post-disaster (ex post)</th>
<th>Security for loss of assets (households/businesses)</th>
<th>Security for relief and reconstruction (city and central governments)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-market</td>
<td>Emergency loans; money lenders; public assistance</td>
<td>Diversions; loans from World Bank and other IFIs</td>
</tr>
<tr>
<td>Inter-temporal</td>
<td>Kinship arrangements</td>
<td>International aid</td>
</tr>
<tr>
<td>Market-based risk transfer</td>
<td>Micro-savings</td>
<td>Catastrophe reserve funds, regional pools, contingent credit</td>
</tr>
<tr>
<td></td>
<td>Property and life insurance</td>
<td>Insurance or catastrophe bonds (also index based)</td>
</tr>
</tbody>
</table>

Table 2 Examples of pre- and post-disaster urban risk financing arrangements (Based on Linnerooth-Bayer and Mechler (2007)).

Fig. 2. Budget and resources of FONDEN (from Ministry of Finance and Public Credit of Mexico).
on the total amount of expected claims adding to the remaining available funds. In addition, donors are adding to the reserves. The governments of Bermuda, Canada, France, the United Kingdom, as well as the Caribbean Development Bank and the World Bank recently pledged a total of US $47 million to the CCRIF reserve fund (see Fig. 3). Part of this funding is used to help low-income island states, such as Haiti, pay the requisite premium (Ghesquiere, Mahul, Forni, & Gartley, 2006; World Bank, 2007).

There were clear advantages of pooling their risks, and thus diversifying across island states. Together, governments can negotiate re-insurance terms for their pool at a significantly lower cost than if they were to purchase insurance separately in the financial markets. Early cash claim payment received after an event will help to overcome the typical post-disaster liquidity gap.

Evaluating the regional (Asian) megacity risk pooling

Precedents exist for transferring public-sector risk, and it seems straightforward to explore whether the Mexican and Caribbean examples could provide a sort of blueprint for a megacity disaster risk pool in Asia and elsewhere. Many factors are worth considering and, in the following section, we focus on the need and associated benefits for regionally pooling Asian megacity risk. We propose (Table 3) to consider the following criteria, identifying the need and applicability of risk financing for megacities: (i) feasibility and practice of risk assessment; (ii) the demand for risk management; (iii) scope for diversification and (iv) issues of urban governance and financial capacity to transfer risk as well as absorb indemnity payments.

Assessing megacities disaster risk: drivers and consequences

Natural disaster risk is commonly defined as the probability of potential impacts affecting people, assets or the environment. The standard risk assessment approach (see Fig. 4) is to understand natural disaster risk as a function of hazard, exposure and vulnerability (e.g. see, Banks, 2005; Gurenko & Lester, 2005; UNISDR, 2004).

Hazard analysis involves determining the type of hazards affecting a certain area and their specific intensity and frequency. Assessing exposure involves analyzing the relevant elements (population, assets) exposed to hazard(s) in a given area. Vulnerability, arguably the key variable for translating a natural phenomenon into a source of risk), is multi-faceted and comprises a number of drivers and factors, such as:

(i) physical – related to the susceptibility to damage engineered structures such as houses, dams or roads. Also factors such as population growth may be subsumed under this category;
(ii) social – defined by the ability to cope with impacts on the individual level as well as referring to the existence and robustness of institutions to deal with and respond to natural disaster;
(iii) environmental – a function of factors such as land and water use, biodiversity and stability of ecosystems;
(iv) economic – refers to the economic or financial capacity to refinance losses and recover quickly to a previously planned activity path. This may relate to private individuals as well as companies and the asset base and arrangements, or to governments that often bear a large share of a country’s risk and losses.

Operational approaches range from more top-down (such as those often used in the insurance industry) to bottom-up ones (such as those used in community-based vulnerability and risk assessments), using detailed quantitative methodologies from the natural, engineering and economic disciplines on the one hand (see Grossi & Kunreuther, 2005) or more qualitative methods based on social, cultural or behavioural discourses on the other (see Verweij & Thompson, 2006). Both approaches have their merits and it is generally recognized that employing combinations of those is often most effective (Hochrainer & Mechler, 2009).

It seems straightforward to follow this disaster risk assessment framework for megacities, following the main principles of catastrophe risk modeling depicted in Fig. 4. Yet, there are a number of specific issues well worth considering.

Time scales

As Table 4 shows many urban planning decisions relating to the management of urban disasters involve long time horizons, which may even extend to 200 years.

However, it is important to know that there are difficulties for systematically establishing an estimate of risk in terms of probabilistic consequences even for single hazards for urban areas involving megacities. Based on a detailed assessment of risk assessment methods for Asian risk, including megacity risk, ADB (2007) finds

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Degree to which this is met for Asian megacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility and practice of risk assessment</td>
<td>–</td>
</tr>
<tr>
<td>The demand for risk management</td>
<td>+</td>
</tr>
<tr>
<td>Scope for diversification</td>
<td>+</td>
</tr>
<tr>
<td>Megacity governance and capacity to transfer risk</td>
<td>+</td>
</tr>
</tbody>
</table>
India’s GDP and similar figures can be gathered for China. Large Mumbai, Chennai, Calcutta and Delhi contribute a total of 15% to economic powerhouses of their respective countries. India and China megacities can be of the scale comparable to many national economies (Fig. 5). Manila, Dhaka, Karachi and Jakarta are the key economic activity and value added to GDP of

Another issue of complication is the indirect and second-order effects. Only recently have those second-order effects received more emphasis as important components in risk assessments and management decisions. Incorporating follow-on indirect effects seems important as economic activity and value added to GDP of megacities can be of the scale comparable to many national economies (Fig. 5). Manila, Dhaka, Karachi and Jakarta are the key economic powerhouses of their respective countries. India and China are more diversified, yet the five major Indian cities Bangalore, Mumbai, Chennai, Calcutta and Delhi contribute a total of 15% to India’s GDP and similar figures can be gathered for China. Large disruptions in such cities may therefore also cause economy-wide disruptions. What is more, megacities in Asia are often considered to serve a gateway function to the global economy and also, as those cities exhibit a high percentage of skilled labour, natural disasters may result in the economic disruption of entire regions (ADB, 2008; van Dijk, 2007).

Yet, so far there has been little reported evidence of megacity disaster events causing substantial economy-wide disruptions, Munich Re (2004) even concludes, that although megacities are considered key engines and gateways of growths, the overall indirect-follow on effects of disasters, may be relatively short-lived and moderate. On the other hand, the same report warns of accumulation risk within megacities which is defined as the spread of risks from one megacity sector to another, increasing the loss burden substantially. Hence, differentiation between direct and secondary effects is important in determining the right mix between risk reduction and risk financing, which will be discussed next. As a key priority for research, more evidence is clearly desirable on channels and magnitudes of megacity-disaster follow-on impacts.

**Identifying a demand for risk financing**

A need and demand for risk management solutions relates to exhibited or assumed risk preferences of the agents exposed to risk. Agents are risk averse if they are willing to pay more than their expected losses to avoid the risk of incurring very large losses at one time. This rationale is highly relevant for poor households and farms, where a large loss (e.g., the loss of crops from a drought) can threaten livelihoods and lives if victims cannot rely on informal risk-financing and self-insurance mechanisms. Meso-scale agents, such as microfinance institutions, marketing cooperatives and even donors, are risk averse if they cannot easily recover from large co-variant losses (e.g., if a drought leads to massive loan defaults). In contrast to individuals, governments of developed countries are often not, in theory, risk averse, and thus in most circumstances should not purchase insurance, but rather self-insure (in Sweden, insurance for public assets is illegal). This is the result of a well-known theorem by Arrow and Lind (1970), who give two reasons for the risk neutrality of the public sector. First, if the government spreads its risk over its citizens (most usually by means of taxation), the expected and actual loss to each individual taxpayer is minimal due to the sheer size of the population. Second, a government’s relative losses from disasters, in comparison with its assets, may be small if the government possesses a large and diversified portfolio of assets.

Neither of these reasons applies to highly exposed, small or low-income countries that have over-stretched tax bases and highly correlated infrastructure risks (Hochrainer & Pflug, 2009; Mechler, 2004). Realizing the shortcomings of after-the-event approaches for coping with disaster losses, sovereign insurance has become an important cornerstone for tackling the substantial and increasing effects of natural disasters (Gurenko, 2004). This

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**Table 4**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Exposed agents</th>
<th>Time scale (year)</th>
<th>Spatial domain of planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy production (e.g., nuclear plant cooling systems affected by droughts)</td>
<td>Public and private</td>
<td>20–70</td>
<td>x</td>
</tr>
<tr>
<td>Water infrastructure (e.g., dams, reservoirs)</td>
<td>Public and private</td>
<td>30–200</td>
<td>x</td>
</tr>
<tr>
<td>Building and housing (e.g., flood proofing)</td>
<td>Public and private</td>
<td>30–150</td>
<td>x</td>
</tr>
<tr>
<td>Transportation infrastructure (e.g., port, bridges affected by flooding)</td>
<td>Public and private</td>
<td>30–200</td>
<td>x</td>
</tr>
<tr>
<td>Coastline and flood defences (e.g., dikes, sea walls)</td>
<td>Public</td>
<td>&gt;50</td>
<td>x</td>
</tr>
<tr>
<td>Land-use planning (e.g., in flood plains or coastal areas)</td>
<td>Public</td>
<td>&gt;100</td>
<td>x</td>
</tr>
<tr>
<td>Urbanism (e.g., urban density, parks)</td>
<td>Mostly public</td>
<td>&gt;100</td>
<td>x</td>
</tr>
</tbody>
</table>

*Fig. 5. Megacity contribution to national GDP in Asia in 2005 and projected for 2020. Source: PricewaterhouseCoopers (2007), World Bank Indicators (2007) and own calculations.*
message, for example, became clear to the Mexican authorities after experiencing the 1985 earthquake in Mexico City.

Based on the above discussion, city governments may estimate risk in combination with the availability of loss financing resources (financial ability to cope) (see Fig. 6), eventually leading to a threshold level where additional cover and funding is needed to finance the incurred losses if a given magnitude (or layer of risk) is exceeded (a detailed example for such a threshold approach for one Caribbean country, namely Grenada, can be found in Hochrainer and Mechler (2009)).

Depending on the remaining risk and corresponding risk layer then, risk reduction and/or risk financing options may be determined (Table 1 and Fig. 1). Similar thinking was actually used for the Mexican transaction (see Cardenas et al., 2007).

Diversification

A key criterion for the Caribbean initiative was that hurricane (and to lesser extent earthquake risk) was considered not diversifiable by the exposed countries, and difficult to spread for one country alone. Regional risk pooling reduces costs and enhances cooperation. A key consideration was the degree of (none)-correlation of risks. Since natural disaster risk among the island states is not perfectly correlated, the variability in a pool is less than the combined variability by the individual states. Correlation between individual states varied from zero to 88% for hurricanes. Due to the insurance pool, the coefficient of variation, e.g. the ratio between the standard deviation and the expected loss, is approximately reduced by a factor of 3 when countries risks are aggregated. For the Caribbean regional pool, it was calculated that individual insurance premiums were reduced by almost half due to the diversification effect (World Bank, 2007). Diversifying Asian megacity risk seems to be feasible and would seem to reduce costs. As Fig. 7 shows, at a first glance, flooding, earthquake and typhoon hazards seem to affect Asian countries and cities differentially and not all at the same time. Therefore, resulting risks seem to be relatively uncorrelated. Further analysis along the lines of the Caribbean pool would clearly be of high importance in order to devise a sufficiently regionally diversified megacity disaster risk portfolio.

Especially in light of Fig. 5, secondary (follow on) effects due to natural disaster events in megacities could be increasing up to the macroeconomic level, making such insurance and pooling arrangements even more attractive.

Megacity governance

GlobeScan and MRC McLean Hazel (2008, p. 57) suggest that Metropolitan governance has become increasingly complex as cities have morphed into agglomerations combining multiple administrative organizations and jurisdictions. This has led to calls for a complete reassessment of urban governance. Megacities also need innovative funding strategies to release much-needed investment to address the infrastructure challenges.

This is echoed when studying megacity disaster risk management approaches in a snapshot analysis for selected megacities. For example, as promoted by the EMI, in order to mainstream disaster risk management effectively into local city planning, and achieve a sustainable long-term process, it needs to be integrated within each of key city functions while strengthening various institutions. As shown in Fig. 8, one of the key components is financial authority.

Funding constraints and opportunities are generally being discussed in EMI case studies1 and a diverse picture emerges. When evaluating insights for two key Asian megacities, Manila and Dhaka, it becomes clear that lack of tax and funding authority is a key challenge for megacity governments. In the Manila city profile, the need to leverage money for DRM in a safer and more reliable way is mentioned, given the fact that Manila cannot independently levy or collect taxes and depends solely on central government funding for disaster management spending. Metro Manila has a calamity fund on its own, which is 5% of estimated revenue from “regular sources”, set aside as lump sum appropriations for relief, etc. Insurance and re-insurance are mentioned as tools to leverage additional

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1 See http://www.pdc.org/emi/emihome.html.
funding tools to deal with the impacts after a disaster. In Dhaka, decentralization is less advanced and disaster risk management arrangements being discussed are at the national level, since Dhaka is treated as a part of the country, despite the facts that it requires special treatment due to its megacity characteristics.

**Conclusion**

Recently, interest has emerged in exploring whether megacity disaster risk may be suitable for a regional risk pooling scheme, broadly similar to what was done in Mexico and in the Caribbean. This paper has been written as input to concurrent discussions triggered at multilateral financial institutions concerned with rising losses as well as their implicit role as reinsurers of last resort for such risk. Tentatively, we are finding that megacity disaster risk in developing countries is highly dynamic and difficult to assess, often comprising substantial amounts of informal settlement risks. Furthermore, incentives for risk reduction are not there yet and risk management uptake is low. This may limit insurance applications considerably, but a key risk opportunity may relate to thinking about insuring public sector liabilities for infrastructure, liquidity support and relief to population, as it was conducted by Mexico on a country-basis of earthquake risk as well as the Caribbean and regional pooling of hurricane and earthquake risk using parametric instruments. We explored the rationale behind those transactions, and discussed conditions for conducting similar transactions for Asian megacity public-sector risk.

A finding is that the case for regional megacity risk pooling needs to be better established with thresholds to be determined, risks clearly defined and financial authority better segmented. Also, in order to motivate insurance, a case needs to be made for risk aversion of megacities, which would entail better assessing channels and magnitudes of megacity-disaster follow-on impacts, supposedly affecting whole countries and regions. IFIS, incl. ADB and donors have a key role to play in terms of technical assistance, subsidizing pooling, etc. Donor assistance is needed and could take many forms, including technical support for feasibility studies and capacity building, and financial support in the form of re-insurance and subsidies. It could be extended to regional schemes, but also at local, national, and global levels, complementing each other and leading to better global risk diversification and, as a consequence, reduced premiums. Without this assistance, insurance programs will not be viable in many highly exposed developing countries. Because of the high costs of insuring correlated or covariate disaster risks (which may affect whole regions at the same time), individuals can be expected to pay substantially more than the
expected losses they will experience over the long term, which is neither feasible nor desirable without donor support. Donors can also ensure the proper design of contracts to reward risk-reducing behaviour and thus avoid “moral hazard”, which means that individuals take fewer precautionary measures because they are insured. Such scheme can only be considered one element of the multi-dimensional problem of disaster risk and management for megacities and has to be placed within an integrated approach including legal issues, distributional aspects, and the mainstreaming of disaster risk into development planning processes. Such approaches help detect most promising options of risk prevention via structural or soft mitigation measures, as well as the increase in financing capabilities, including instruments such as reserve funds, contingent credit arrangements and insurance options. As stated in the beginning and throughout the text, several conditions have to be met to increase the chances for the implementation. To this effect, one concrete suggestion is to focus on stimulating a broad process-based dialogue, such as the one started in the Caribbean in the aftermath of severe hurricane seasons of 2005 and 2006, eventually leading to the implementation of the Caribbean pool in 2007.

References


