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After Sandy – rethinking flood risk management in Asian coastal megacities

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The tropical storm, and for a time hurricane, named Sandy arrived on the US East Coast on 30th October 2012, and delivered a 5.1 meters storm surge, the highest since 1851, to the heart of the country's financial hub in the Lower Manhattan area in New York City (Figure 1) (NOAA 2012). As a result, there were more than 40 fatalities across the city, and the storm-related death-toll across the North East US reached 63. 69 deaths in the Caribbean region meant that total casualties caused by the storm was 132 (BBC 2012; Fischetti 2012). Public transport systems were submerged; the runways of two major airports (John F Kennedy and Newark) were flooded and closed; and the New York Stock Exchange was shut-down for two days. The forecasting

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firm Equcat estimated the likely total cost of damages to be over $85 billion (Reuters 2012a). Reuters estimated damage of at least $18 billion in the area between downtown and Long Island alone (Reuters 2012b). To put this in context, average annual losses from cyclones, storm surges, coastal floods and winds in the US are estimated to be in the region of just $10 billion per year.

Although the magnitude of Sandy was less intense than Katrina in 2005, Sandy affected a larger area; NASA (2012) reported the strong winds (greater than 65 km/h) for a distance of approximately 500 km during Hurricane Katrina, whereas Sandy prevailed for over 1,500 km at a similar intensity. This is possibly the main reason why Sandy generated sea surges over a larger coastal area than Katrina, and affected more than 12 states on the East coast (CCTV 2012).

Previous research (Webster et al. 2005), has indicated that the frequency and intensity of cyclones (i.e. hurricanes and typhoons) has increased in the last 50 years, and that the trend is expected to rise continuously this century due to climate change. The IPCC (2012) also reported that it is likely that there has been a pole-ward shift in the main Northern Hemisphere extra-tropical storm tracks, which means that the potential for intense storms that produce significant wind and extreme rainfall is slightly increased.

The impact of Storm Sandy reflects the vulnerability of coastal megacities across the globe. This vulnerability exists because human settlement, including properties and infrastructure, is mostly located in low-lying flood-prone areas similar to those of New York City. The major financial hub of Wall Street for example, is just a mile away from the harbor. An accepted definition of a megacity is a city with a population of 8 million or more (United Nations 2010). New York City has 8.2 million inhabitants, approximately 2 million of whom live on Long Island or smaller islands and in flood-prone areas. The city government realised that it would be impossible to relocate this number of people and associated assets outside of the hazard areas, and have therefore started to adapt the flood management strategies in preparation for climate change (NYC 2012). Adaptation practices such as assessment of surge-risk, flood-risk mapping, prediction of risks from various climate scenarios, and enhanced emergency evacuation plans have been implemented since 2010 (Klima et al. 2011).

The city's storm warning system was activated some 41 hours before Storm Sandy arrived, at which point the city authorities announced the closure of the financial markets and advised residents to stock-up on food and water. Recommendations to employ sand-bags for flood-proofing and property protection, and advice to residents to stay at home or move to safe areas in preparation for the storm, were examples of good practice (BBC 2012). Without such measures, it is highly likely that the casualty count and damage caused by the storm would have been much worse.

Figure 1. Up to 5.1-m tidal surge overtopped embankments along the coastline (Lucas Jackson, photographer; with permission from Thomson Reuters)

Looking across the coastal regions of Asia, most coastal megacities have developed within the last three decades. During the 1960s Tokyo was the only coastal megacity in Asia, whereas now there are seven (Osaka-Kobe, Shanghai, Jakarta, Manila, Seoul, Guangzhou, Shenzhen and Hong Kong). The fact that these coastal cities are ports means that their economic policies are oriented towards trading and exporting products. Asian countries like China and Vietnam have established Special Economic Zones (SEZ) in coastal cities (e.g. Shenzhen) which give special tax incentives for foreign investors to encourage international trade and investment. This leads to higher rates of employment and business opportunities. For example, the former fishing town of Shenzhen has grown from just 300,000 people in 1979 to over 8 million at the present time (including guest and itinerant workers). A number of other Pearl River Delta cities have recorded similar growth rates within the last three decades (Yeung 2011). Emerging coastal cities in South East Asia also appear to be following the success story of the Chinese SEZs. Yangon in Myanmar for example recorded a population growth of 22% over the last decade as the government opened its doors to economic reform (Seto 2011).

All coastal megacities in South East Asia are exposed to storms (cyclones/typhoons) similar to Storm Sandy and many have suffered from a number of severe sea surges and inundations in recent years. Typhoon Nargis in 2008 for example, inundated land up to 75 km inland in the Rangoon and Irrawaddy Delta areas on the south coast of Myanmar; which resulted in the death of over 146,000 people, and total economic damage of over $17 billion (Syvitski et al. 2009). Similarly, storm surges driven by Typhoons Hagupit and Koppu in 2008 and 2009 respectively, inundated the low-lying coastal areas of Tai O town in Hong Kong, damaging over 100 properties. Most of the city infrastructure (e.g. business and residential properties) are unfortunately located on flood-prone areas. Shenzhen is another example of a high-risk area, as many properties have been built in flood-prone areas (such as the Harbour-front area). Even as the city becomes increasingly urbanised (up to over 98%), the demand for land is still increasing (Luo and Shen 2012). As the availability of land decreases, the municipal government has started to develop the Futian coastal wetland area, which previously functioned as a flood-storage area.

More than 86% of the Pearl River Delta's coastal areas currently rely on hard flood-protection measures such as dykes and embankments, but only a limited proportion of these are designed to withstand a 1-in-100 year event of a similar scale to Storm Sandy (Chan et al. 2012). In fact, existing flood management practices in many coastal megacities in Asia are devoid of planning, projections and adaptation strategies that account for future climate-change, and are thus unprepared for extreme storms such as Storm Sandy. Given these circumstances and the likelihood of future climate change, a number of researchers have cautioned that Asian coastal megacities, both existing (e.g. Shanghai, Guangzhou, Hong Kong, Bangkok, Yangon, Tokyo, etc.) and emerging (e.g. Ningbo, Tianjin, etc.), will be particularly vulnerable as they are facing common constraints caused by rapid growth (i.e. populations and economic), urbanisation and land scarcity (AFP 2012; Balica et al. 2012; Hanson et al. 2011).

This situation suggests that, although unpalatable to land planners and decision makers, measures such as prevention of further development on floodplains, remain the most effective way to avoid flood damage. Such measures should be combined with hydrological modelling and flood-risk mapping and forecasting to assist planners in making well-informed decisions. Before achieving these objectives, there are two issues that should perhaps first be considered. Firstly, it is difficult to rely purely on statistical assumptions and the use of climatic modelling to extrapolate future extreme events (i.e. precipitation and storm patterns), that have not yet been observed (Schnoor 2008). Accordingly, it will be difficult to accurately predict future hydrological changes and cyclonic effects in coastal cities associated with future climate change. Secondly, not all coastal megacities have undertaken good flood-risk management practice, such as the design of early warning systems, and emergency excavation and flood relief plans (as had been done in New York). Indeed, most cities in Asia are still reliant on wholly engineering-based flood defence, without the benefits of holistic flood management, such as preparedness, awareness and emergency evacuation plans to cover all parts of the city. The most recent coastal floods in Hong Kong for example, reflected a flood warning system that is only operational for certain parts of the city. There was no comprehensive flood emergency evacuation plan, and the institutional responsibilities related to coastal flooding were blurred (Chan et al. 2012).

The reality for many SE Asian coastal cities then, is that far too many developments have been placed in floodplains and many new plans continue to focus on developing these areas. This pattern seems unavoidable on the Asian coastline which is subject to huge population and economic growth. However, we need to constantly remind people that these low-lying floodplains are naturally exposed to floods and cyclonic effects (Syvitski and Kettner 2011). In addition, it is expected that climate-induced sea-level rise will increasingly affect these megacities.

Relocation is impossible in the megacities due to their huge settled populations, and is surely the last option in terms of socio-economic control. Whilst strategic abandonment in areas of particularly high risk would at least ensure people’s safety (Neville and Coats 2009), abandonment would also lead to difficulty in relocating large numbers of residents to other areas. Municipal governments therefore, have to raise their resilience and safety level as the first priority. This can be done through practices such as utilising flood-proofing techniques;

enforcing emergency evacuation and design of flood relief plans (e.g. ensuring emergency food and freshwater storage, interconnecting with various emergency service departments – medical and police, temporary shelters and financial supports) (Cheng 2006); improving flood warning systems to ensure people can respond and react in time (Ma et al. 2010); educating the public to prepare for storms and floods; and starting to reform the spatial landuse and planning system to address flood risk (Porter and Demeritt 2012).

In conclusion, lessons from Storm Sandy and Katrina imply that it is just not possible to comprehensively protect coastal megacities from extreme storms and the resulting floods. Increasingly unpredictable climatic impacts mean that embankments and flood gates are will always have the potential to be breached during such extreme weather conditions. To ensure our safety and the safety of the infrastructure that we rely upon requires us to continually learn and re-evaluate our approach to flood management. Living with storms and being vigilant in our preparations will make us more resilient and adaptable to the changing levels of flood risk likely to be faced by future generations. It is also imperative that lessons are shared internationally (Knight et al., 2006), as whilst each city has its own local characteristics, whether physical, social, economic or institutional, cities can learn much from each other's examples, particularly where significant events have recently occurred.

In economies experiencing rapid growth it is tempting to reject any measures that might reduce the capacity for economic development, but the potential impact of an event such as Sandy in a city that has not adequately considered these issues could lead to a high loss of life and an even greater impact on economic growth. Flood hazards are increasingly connected to, and can have an impact onthe world economy. For example, Chongvilaivan (2012) reported that the 2011 Thailand floods indirectly affected a number of their trading partners. Japan's automotive exports industry in particular, experienced a decline of 24.1% in the December following the floods, as Thailand is a major customer for vehicle parts and components. Fujita and Hamaguchi (2012) found similar impacts on the production networks of the automotive industry after the tsunami and catastrophic floods in Japan in March 2011, which recorded an export capacity drop of 39% in China. Such negative impacts in any of the Asian megacity regions would undoubtedly have implications for economies across the globe particularly when they are already in a fragile state.

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