COASTAL MEGACITIES: risks and opportunities

Every year, more and more people are flocking to live near the sea's edge, often congregating in massive cities. **Sophie Blackburn** and **Mark Pelling** explore what happens when urban and coastal zones collide.

In a 24-hour period beginning on 26 July 2005, Mumbai was lashed by over 900 millimetres of rainfall – almost half the average rainfall it receives in an entire year. Hundreds of people died in the ensuing flooding – exacerbated by the high tide on the evening of the 26th – and the city also suffered serious economic losses. What made this megacity of 21 million people particularly vulnerable was a combination of extreme precipitation, unplanned urbanisation and coastal location. Sea-level rise and coastal subsidence induced by human activities will only exacerbate the risks to megacities such as Mumbai (Figure 1). But megacities aren't merely passive actors: they reshape coastlines, affect sensitive ecosystems, pollute air and water and influence local and regional weather systems. The relationship between megacities and coasts is thus a dynamic one involving human and environmental processes.

Megacities in Europe and the Americas aren't growing much; some are even on the decline. But in the developing world such cities are sprouting up at a fair clip. Between 1975 and 2000 the number of megacities in low- and middle-income nations increased from two to 13. Of the 23 megacities worldwide in 2011 (UN-DESA 2012) 16 were coastal. One trend common to large cities across the world is the growth in urban sprawl; in the high-income nations such growth is up to twice as fast as population growth (Angel *et al.* 2011). Both the demographic and spatial growth of coastal megacities is changing the ways in which risk is constructed and experienced, particularly in the context of climate change.

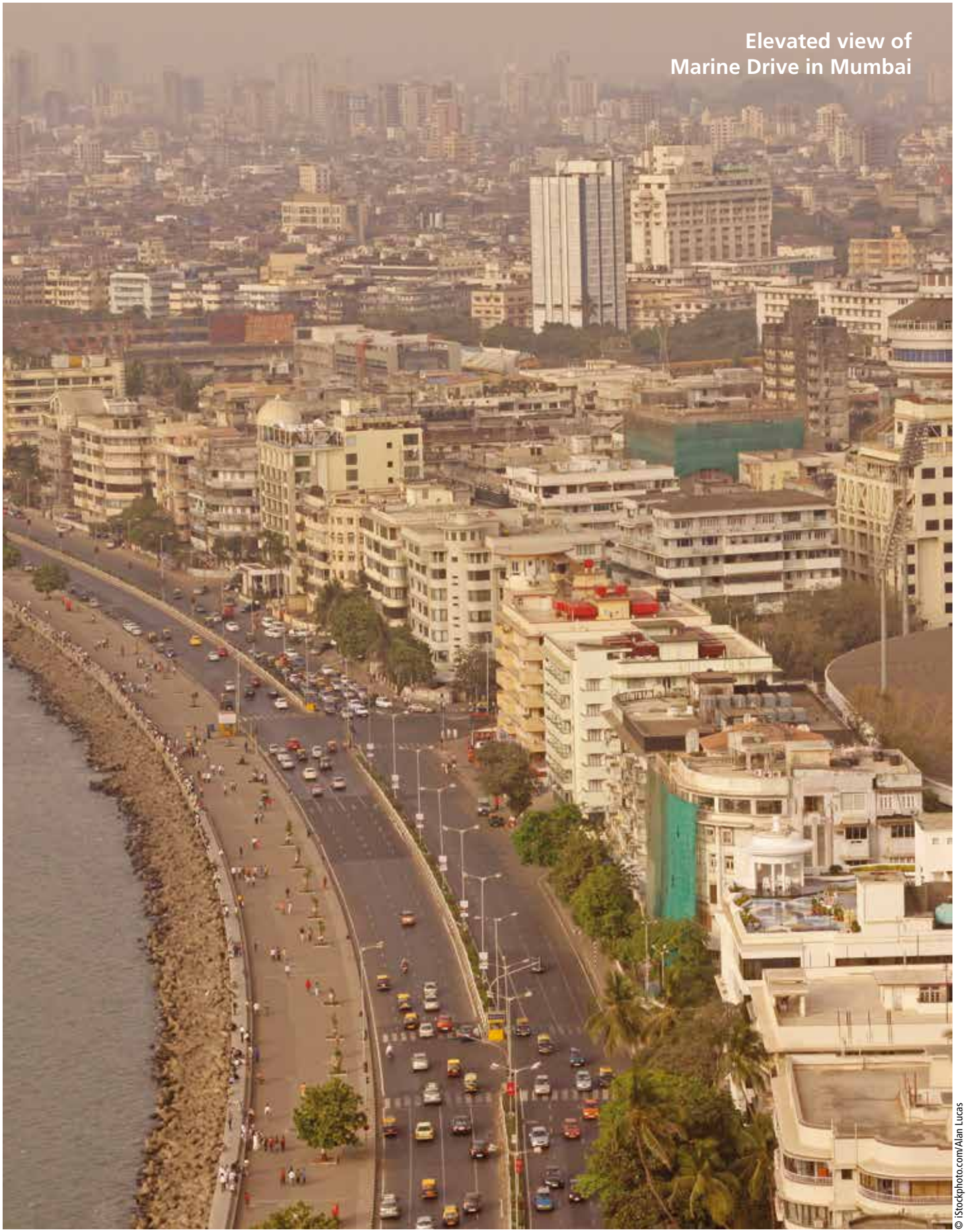
The urban poor are almost always the most at risk.

The city-coast duel

The susceptibility of a coastal megacity to natural hazards is determined by geographical location as well as the socio-economic and political context. Storms and storm surge, extreme precipitation and flooding are some frequently encountered hazards. Making the situation worse is the combination of sea-level rise resulting from climate change and local sinking of land resulting from, for example, sediment compaction and over-extraction of groundwater.

The capacity of coastal megacities to adapt is constrained by the scale and complexity of critical infrastructure, land-use and governance. Governance includes local to national interests across the public, private and civil-society sectors, often in partnerships and with overlapping or sometimes contradictory responsibilities and interests. The quality of governance and the degree of social inequality are primary determinants for the severity of disaster impacts: the urban poor are almost always the most at risk. While it is the rich who lose most in absolute economic terms such losses, at least in the developed world, are nearly always covered by insurance. The 2005 flooding in Mumbai, for example, affected slum dwellers and other urban poor disproportionately. It exposed the unplanned nature of urbanisation and poor implementation of the existing disaster mitigation strategy.

The coastal zone itself tends to take quite a beating from megacities. Settlements grow along the shoreline as opposed to inland and fortify themselves by sea walls and levees. Air pollution disturbs



Elevated view of Marine Drive in Mumbai

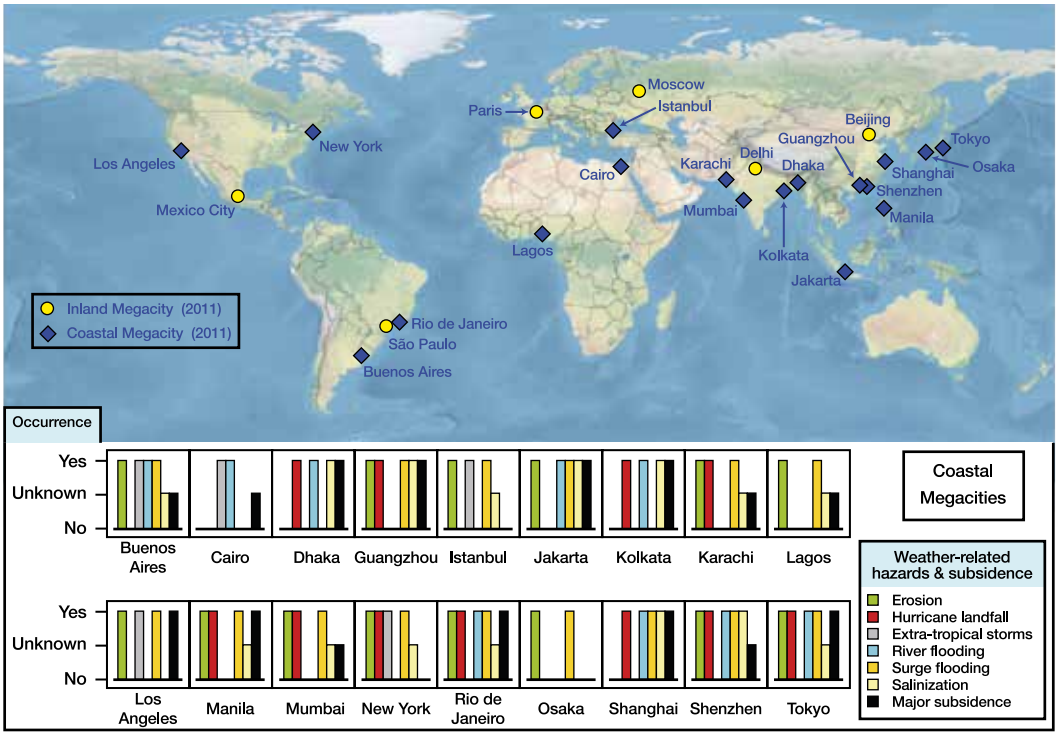


Figure 1: Major weather-related hazards and subsidence occurrence for coastal megacities. The coastal zone is defined here as the area within 100 km from the coast. Note that Dhaka and Cairo are included as megacities despite being more than 100 km away from the coastline: this is to account for the strong influence of the coast on these cities.
Source: Pelling and Blackburn (2013, Plate 4.3)

biogeochemical processes in the coastal ocean (von Glasow *et al*. 2012). Where topographic barriers inhibit the expansion of coastal cities, industrial and building activity is likely to be even more heavily concentrated with its attendant environmental impacts. In Ghana, for example, anthropogenic activities account for the vast majority of coastal erosion. Perhaps least well understood is the interaction of urban form and weather systems in the production of the Urban Heat Island effect in coastal cities. Although some of this effect is mitigated by a coastal location, warming above regional values is a norm for megacities. Where air pollution is high, for example in Tokyo, this is compounded by the Urban Heat Island effect (Yoshikado and Tsuchida 1996). Better known effects include the impact of untreated wastewater and sewage into coastal seas: Manila, for example, currently treats only 17% of wastewater (Pelling and Blackburn 2013). Urban growth threatens the quality of entire water systems, including Kake Taihu close to Shanghai and Jakarta Bay (Shao *et al*. 2006).

Globalisation introduces its own complexities.

Assessing risk

Risk assessments for coastal megacities have not yet fully encapsulated the dynamic interactions between environmental and anthropogenic forces. This is because of the complexity introduced by, for example, non-linear responses and feedback loops that can rapidly trigger potentially unexpected outcomes. One way of unpacking this complexity is to conceptualise risk as the nexus of three domains. The domain of environmental quality includes aspects such as resource depletion and ecosystem degradation. Natural hazard encompasses a wide range of hazards at a variety of scales. Socio-political and institutional context represents such pressures as population growth, governance regimes, political stability/instability and trade; these determine particular modes of urban development and patterns of vulnerability.

Urban population growth (largely because of migration) provides an example of how the different domains interact to generate risk. Population growth generates demand for food, water, energy and land. This may translate into the depletion of coastal ecosystems such as fish stocks and the destruction of wetland habitats. The degradation of mangroves and salt flats removes what would have served as a buffer against storms and coastal surges; it thereby heightens social and economic risk.

Whereas impacts can be highly localised, they can also aggregate and operate at a much larger scale. For example, models indicate that New York City and Tokyo modify the atmospheric flow within their confines and thereby affect regional weather systems. Such processes may introduce new drivers of risk in the context of climate change. However, such outcomes are not readily predicted from historical observations and the modelling of risk at the megacity-coast interface is thus difficult.

Globalisation introduces its own complexities. Megacities are connected to and co-dependent on other regions of the world. A crop failure or extreme-weather event in one part of the world can have drastic impacts on global markets, with knock-on effects on economic and social vulnerability of megacities.

Responding to the challenges

The complex challenges confronting megacities demand policy and research agendas that are innovative and forward thinking. We need to develop an international, integrated data archive for coordinated risk management and knowledge

sharing. This should be coupled with long-term monitoring and model refinement. Finally, we need to better understand how global connectivity as well as feedbacks between natural and social systems could amplify risks and increase their unpredictability. These recommendations hold for other settings too, but the stakes in megacities are particularly high given the rapid increase in populations and assets at risk, the combination of local and global environmental change, and the potential for dangerous feedback loops.

In short, effective governance is a prerequisite to managing the risks that cities face and are perhaps most acute on the coast. Aspects such as health, economy, poverty, education, demography, gender, culture and the environment will need to be considered simultaneously. Because of the interlinkages between the risk domains discussed above, urban planning that prioritises either the environment or the society will not be sustainable. A holistic approach is called for.

Fortunately, megacities are well placed for the development of innovative solutions. In addition to being well connected, such cities possess a concentration of assets and expertise, and are hubs of political, academic and private-sector activity. Hence, they offer fresh opportunities for collaborative and complementary adaptation responses.

Megacities and global sustainability

As sites of consumption and nodes in the networks of global trade, large cities occupy a pivotal position in struggles towards global sustainability. There is no denying that the tremendous social and environmental impacts of the dominant model of mega-urbanisation present a hurdle to sustainable development.

Economic growth of an individual megacity might, at first glance, appear to be a positive step towards sustainability. Sanitation improves over time and air pollution decreases. However, many of the improvements are possible only by load displacement (eg, Hornborg 2011): this is the process whereby environmental gains in one region come at the expense of pollution elsewhere (or even globally). Many of the gains in average wellbeing might reflect the reliance on cheap, migrant labour that often struggles to fully benefit from the gains.

We are beginning to see that this model might not be sustainable in the long term. The collective contribution of coastal megacities to global environmental change is in some ways reflected in their increased susceptibility to sea-level rise and other hazards. Uneven and unplanned growth has translated into the poor living in low-lying, hazard-prone locations and severe modification of natural drainage (for example, the Mithi River in Mumbai). Even in high-income nations the increased interconnectivity of energy, water, transport, communication and security infrastructure has led to compounding risk.

Cities have already transformed their local environments. Adapting to live with global change will likely usher in a new era of environmental and social transformation as the desires for growth and security are rebalanced. Understanding better the interactions between ecological, physical, socio-economic and political processes is a starting point for making transformations that can be deliberate – rather than forced – and, through this process, for enhancing informed and transparent decision-making.

Effective governance is a prerequisite to managing the risks.

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