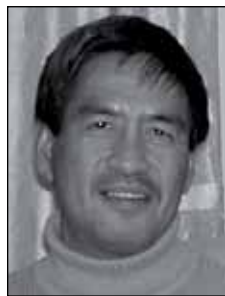


# Natural or Unnatural Disasters: the Relative Vulnerabilities of Southeast Asian Megacities to Climate Change

Presented by **Mr. Rafael Senga**

Manager for Energy Policy in Asia-Pacific - WWF International



Asia is among the regions of the world most vulnerable to climate change. Climate change and climatic variability have and will continue to impact all sectors, from national and economic security to human health, food production, infrastructure, water availability and ecosystems. The evidence of climate change in Asia is widespread: overall temperatures have risen between 1°C and 3°C over the last 100 years, precipitation patterns have changed, the number of extreme weather events is increasing, and sea levels are rising. Because many of the largest cities in Asia are located

on the coast and within major river deltas, they are even more susceptible to the impacts of climate change. This report highlights the vulnerability of some of those cities with the goal of increasing regional awareness of the impacts of climate change, providing a starting point for further research and policy discussions, and triggering action to protect people and nature in and around Asia's megacities from mega-stress in the future.

Cities cover less than 1% of the planet's surface, and are home to around 50% of the world's population, and many of them see a rapid growth trend. Taken together, all cities and urban areas worldwide use 75% of the world's energy and are responsible for 75% of global greenhouse gas emissions. Without major breakthroughs on energy efficiency and emission reductions in cities, we will fail to avoid dangerous climate change in urban as well as rural areas. Cities are hotspots of innovation and technology and have therefore traditionally been the places where many of the solutions to the world's problems have been developed, making all cities potential leaders in the global effort for a low carbon future.

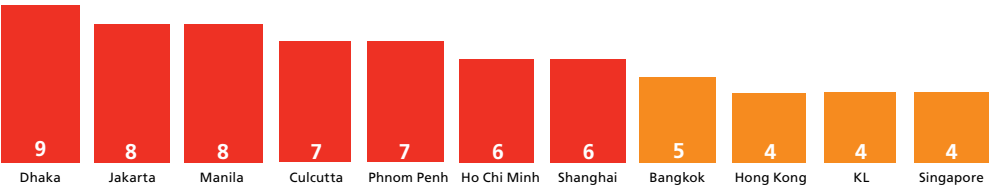
This report focuses on climate variability and the adaptive capacity of cities. It is divided up into four sections: context, methodology, scorecards, and policy. While we highlight the major climate change effects impacting 11 key Asian cities, this summary is by no means an exhaustive review. The cities chosen for this report represent large, mostly coastal cities which are all threatened by climate change. These particular cities were chosen because they represent a good cross section of coastal Asia and the impacts of climate change were assessed as significant. We encourage governments and all other relevant stakeholders to use this report as a catalyst for further discussions on the issue of climate change in the region, deciding where additional research is needed, and what the appropriate policies should be.

For each scorecard, we provide a short profile of the selected city, highlight the observed climatic change, summarize the major climate impacts the city is facing, and suggest some adaptation strategies that may decrease the city's vulnerability. For this analysis, the vulnerability of the cities is a function of their exposure, sensitivity, and adaptive capacity. These three categories were averaged to get the overall vulnerability score. It should be noted that WWF has approached the issue of vulnerability in this report with the most simplistic analysis possible, and we appreciate that there are many additional factors to consider and alternative methods for assessing vulnerability.

Below we highlight the overall vulnerability scores and rank them. However, apart from the overall ranking taking into account all the assessed criteria, this report also summarizes a number of other comparisons including which city is most at risk of environmental threats, which city is most socio-economically sensitive to climate change impacts and which city has the lowest adaptive capacity.

Overall Climate Vulnerability Ranking

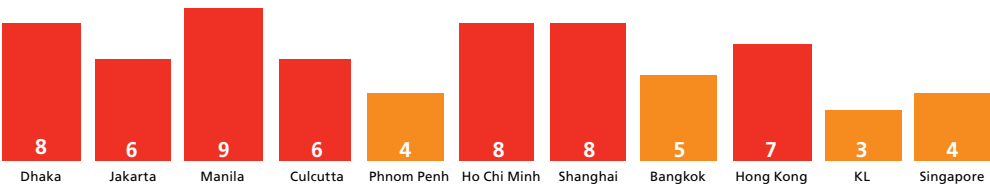
Overall Vulnerability



Of the 11 cities examined, Dhaka in Bangladesh is most vulnerable to climate change impacts. This large, relatively poor city sits just metres above current sea levels, is regularly impacted by tropical cyclones and flooding, and has very limited adaptive capacity. Jakarta in Indonesia and Manila in the Philippines are also highly vulnerable cities and tied for the second rank, largely because of the size of the cities, degree of exposure (both experience frequent flooding), and relatively low adaptive capacity. Calcutta in India and Phnom Penh in Cambodia are tied for third most vulnerable city, largely because Calcutta is prone to salt-water intrusion and sea-level rise effects, while Phnom Penh has very low adaptive capacity. Ho Chi Minh City in Vietnam and Shanghai in China are tied for fourth most vulnerable city, because both are very susceptible to sea-level rise, even though Vietnam and China may have slightly higher adaptive capacity when compared to some of the other cities. Bangkok in Thailand is the fifth most vulnerable city, mostly because it has a relatively high socio-economic sensitivity to impacts (i.e., It has a large population and contributes a large proportion towards Thailand's gross domestic product). Kuala Lumpur in Malaysia, Hong Kong in China, and Singapore in the Republic of Singapore are all tied for the sixth most vulnerable city, mostly because all three have slightly more adaptive capacity than the other cities, even though the climate impacts are still significant.

At Risk: Comparing Exposure To Climate Impacts

Exposure



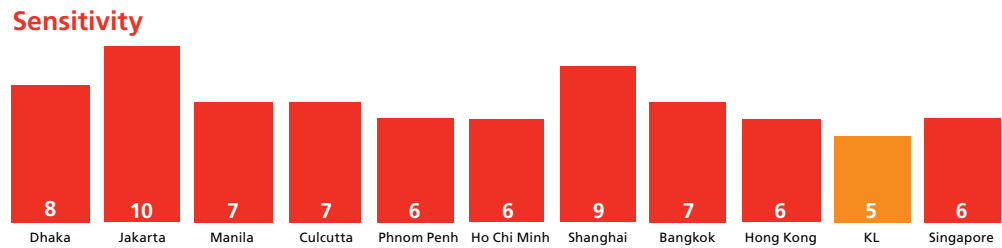
All examined cities will be significantly impacted by climate change, but when examining the selected impacts (tropical storms, sea-level rise and flooding and drought), the report found that some of the cities may experience more frequent or more intense events than others. For this report, exposure is the average of the three highlighted environmental categories including the susceptibility of the city impacted by

1m sea-level rise and 2m storm surge (as illustrated in the satellite photos at the end of each city chapter), historical frequency of extreme weather events including flooding and drought, and frequency of tropical storms and surges. When examining just the exposure to these impacts, we see a slightly different picture from the overall vulnerability ranking.

Manila, largely due to its exposure to tropical cyclones and flooding, tops the list as most exposed. The recent tropical storm Ketsana illustrates this exposure of Manila and the surrounding area to environmental threats. With flood waters reaching nearly 7m and hundreds of deaths during this one storm, Manila is truly vulnerable.

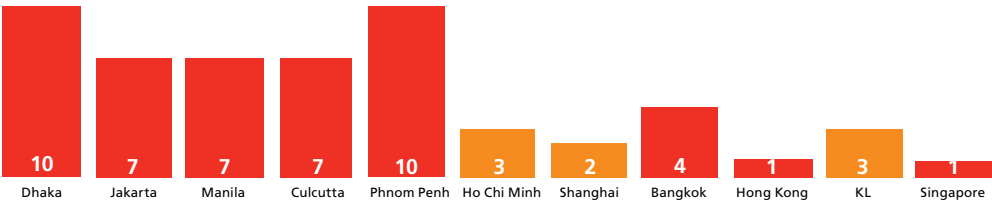
Dhaka, Ho Chi Minh City, and Shanghai tie for having the second highest exposure to climate change impacts, largely because of their susceptibility to flooding and tropical storms. Hong Kong ranks the third highest in terms of exposure to climate change impacts. However, Hong Kong has relatively high adaptive capacity and therefore is overall less vulnerable. Calcutta and Jakarta are ranked as having the fourth most exposure, with Bangkok coming in close in the fifth spot. Not surprisingly, Phnom Penh, Singapore and Kuala Lumpur are ranked at the low end of the exposure scale, but this is not implying that they are not at risk to climate change impacts. All cities examined already see substantial threats with loss of life and significant damage costs, and the situation is projected to worsen in the future.

**Sensitivity Ranking: People, Assets And GDP Under Threat**



The relative sensitivity of the 11 selected cities to climate change impacts is based on population, gross domestic product (GDP), and the relative importance of that city to the national economy. Using these criteria, Jakarta stands out as the most sensitive to climate change impacts. This is largely due to Jakarta's large population and huge contribution towards national GDP. The second most sensitive city to climate impacts is Shanghai for similar reasons. Dhaka is third most sensitive, while Calcutta, Manila, and Bangkok are all tied for the fourth most sensitive. Phnom Penh, Hong Kong, and Ho Chi Minh are fifth most sensitive, while Kuala Lumpur is sixth most sensitive to climate change impacts.

### Inverse Adaptive Capacity



### Preparing To Face The Storm: Adaptive Capacity Comparison

We estimated the adaptive capacity of these 11 cities by examining the overall willingness of the city to implement adaptation strategies (calculated by the number of available adaptation examples and/or responses to previous impacts) and the per capita GDP. It should be noted that a significant caveat of this study is that there are likely quite a number of adaptation examples that cannot be located with desk top reviews. For example, people may come up with their own adaptation strategies in the face of climate change. However, mass media, the internet, and peer-reviewed journals will likely not pick up this information. In essence, the estimates for these 11 cities are just that, estimates based on existing information. For uniformity, we inversed the adaptation capacity numbers so that low adaptive capacity is represented by a larger number (e.g., 10 equates to a very low adaptive capacity). Dhaka and Phnom Penh top the ranking as having the lowest adaptive capacity to climate change.

This is not a surprise as both countries, Bangladesh and Cambodia, are classified as Least Developed Countries by the United Nations. Calcutta, Jakarta, and Manila have the second lowest adaptive capacity. Bangkok is next, with Kuala Lumpur and Ho Chi Minh following. Shanghai has the second highest adaptive capacity, and Hong Kong and Singapore tie for having the highest capacity.

### Policy Recommendations: How To Adapt Mega-Cities To Mega-Stress

It is undeniable, humans have caused climate change and the irreversible impacts resulting from it, and the window of opportunity to limit further damage is quickly closing. As outlined in this report, climate change impacts in Asia are real and happening now. The vulnerability of this region is relatively high and millions of people are being affected.

Fortunately, there are a number of no-regret (win-win) adaptation options that can be implemented immediately and that will help protect people, assets, and natural ecosystems. However, fast action is of the essence as the world has no time left to wait. Climate change and the associated impacts, such as sea-level rise, flooding, droughts and tropical storms will get worse in the future and the costs of responding now rather than later are significantly less. As climate-induced damages escalate, so too do the costs.

In response, the ultimate objective of the United Nations Framework Convention on Climate Change is to stabilise greenhouse gas (GHG) concentrations in order to avoid dangerous climate change. Recent studies indicate that an average global warming of 2°C will result in dangerous and irreversible effects to humans and nature, which rapidly worsen above 2°C warming. The benefits of strong and early mitigation action far outweigh the economic costs of not acting. The costs of avoiding the worst impacts of climate change can be limited to around 1% of global GDP/year, whereas the costs of inaction range from 5 to 20% of global GDP/year. GHG emissions research suggests that the chances of staying below 2°C are getting smaller, but scientists say that it may still be possible. Keeping warming below 2°C with more than a 50% chance

requires global emissions to peak before 2015 and to decline 80 to 95% below 1990 levels by 2050. Therefore, WWF calls on developed countries to cut their emissions by at least 40% by 2020 and at least 95% by 2050 compared to 1990 levels.

This report illustrates the high vulnerability of mega-cities in Asia and provides some general adaptation options. It is also a catalyst for societal discussion about the region's vulnerability, the different types of allowable risk, and what can be done to improve the situation. This will hopefully spark not only discussion about this region, but also in and about other vulnerable regions around the world, as well as about the historical inequality between the biggest polluters and the countries that have contributed the least to climate change but suffer most.

Implementing both mitigation and adaptation strategies is crucial. We need to implement ambitious and effective mitigation policies immediately, achieving peak emissions as soon as possible (but no later than 2015) and maintain at least 3% global emissions cuts annually thereafter. If we want to avoid additional irreversible consequences and even more costs then we need to dramatically reduce CO<sub>2</sub>-eq concentrations to reach less than 350 ppm as soon as possible. Currently the world is estimated to be at 396 ppm CO<sub>2</sub>-eq, including the cooling effects of aerosols in the atmosphere.

Another way of illustrating the limited window of opportunity for staying below 2°C is by examining the total allowable amount of carbon in the atmosphere. In order to accomplish this we must limit all CO<sub>2</sub> emissions from fossil fuels to around 1,000 billion tons of carbon in total from 2010 to 2050, and if we do there would be a good chance (over 70%) that the climate would not warm more than 2°C.

To keep the global average temperature increase well below 2°C, the energy system needs to be altered substantially; we need a new energy paradigm. A below 2°C energy future is realistic and the technology exists to dramatically increase the efficiency of our societies, produce energy with zero-to-low CO<sub>2</sub> and drive innovation.

The challenge rather is a political one whereby decision-making structures must be put in place in order to drive such change. It is not acceptable to dismiss 2°C without having attempted to change the politics so that we can avoid the associated impacts. Vast resources and decision-making structures have been put into place to deal with military conflicts which may have less likelihood of occurring than the impacts from climate change. Governments, businesses, and the scientific community should focus their efforts on delivering this kind of change, rather than slipping into a world where devastating impacts would be the result.

Time is running out and implementing both mitigation and adaptation strategies are of the utmost importance.

It is useful to remember that with both strategies we are not powerless to act on climate change, regardless of our position on the planet or role in governance. There are mitigation and adaptation opportunities for everyone.

Vulnerability is important to assess because planning for adaptation is essentially designing response options to key vulnerabilities. However, no plan should be created for a single vulnerability in a single location, rather effective planning requires that the various responses be woven together into a fabric that is composed of actions that work together to provide the greatest adaptive benefit for the greatest number of vulnerabilities or the highest priority vulnerabilities. To limit these vulnerabilities there needs to be a combination of local and regional adaptation action, and local, regional and global policy efforts to support both adaptation and mitigation. ■

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The full WWF report 'Mega-Stress for Mega-Cities' can be found on their website: [http://www.wwf.org.uk/research\\_centre/?3454/Mega-Stress-for-Mega-Cities](http://www.wwf.org.uk/research_centre/?3454/Mega-Stress-for-Mega-Cities)

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